Flagstaff Watershed Protection Project

Fuels and Fire Report

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For:

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Introduction

This report will address the effects and concerns of four alternatives on the fire hazard and fuels conditions within the project area. In addition, a discussion of the effects on air quality is also included. The alternatives consist of the no action alternative and three different versions of proposed action, including a "minimal treatment" alternative.

The Flagstaff Watershed Protection Project (FWPP) area consists of two distinct areas, the Dry Lake Hills and Mormon Mountain, both with varying topography including slopes greater than 30 percent. The area also contains Mexican spotted owl protected activity centers (PACs) and a mix of tree species requiring different prescriptions for management. In addition, the Mormon Mountain portion of the project area is within a watershed that contributes to the Lake Mary reservoir, a principle water source for the City of Flagstaff. The City of Flagstaff relies on this area to provide water to its residents and visitors. The Dry Lake Hills portion of the project area lies directly north of the city, in a watershed that drains into the city itself (see the Hydrology Report for more information). Therefore, the watersheds' health and sustainability are important to Flagstaff residents.

Currently most of the project area is in a state of extreme to high fire hazard. This report will address existing conditions relating to fire hazard, vegetative condition, and fuel loading conditions of stands within the project area, the projected condition of the project area in the next 20 years if no action is taken and under the action alternatives, desired conditions related to the same measures addressed in the existing condition analysis, the anticipated effects of the action alternatives on fire and fuels resources, and the concerns and issues arising from the different alternatives considered.

Several variables affect fire behavior on a site and over a landscape. Besides weather and terrain, (e.g. slope steepness, aspect, and landform types such as chutes, canyons, chimneys, saddles, etc.), the variables that play the largest role in influencing fire behavior within a forest include dead and live fuel loadings, fuel moistures, crown bulk density (the volume of fuel available in tree crowns), crown base height (the height at which tree branches can be ignited by ground fire), and canopy closure (percentage of ground area vertically shaded by overhead foliage) (Agee and Skinner 2005).

These variables, depending on their structure and arrangement, can create many different fire behavior outcomes for a landscape. Intense fire behavior will most likely occur during hot, dry, and windy weather conditions under forest conditions of high fuel loadings, including a large number of trees per acre, high crown bulk densities, low crown base heights, and large percentages of canopy closures.

Adjective fire hazard rating is used to quantify the intensity with which a fire can burn over a landscape during hot, dry and windy conditions. These weather conditions typically occur from April through July on the Mogollon Rim (where FWPP is located), until a monsoonal weather pattern sets up. Fire hazard ratings assigned to an area reflect the collective effects of fuel loadings, crown bulk density, crown base height and canopy closure on fire behavior if a wildfire were to occur in the same area under 97th percentile weather conditions. 97th percentile weather conditions represent the 3% highest days for fire growth/spread potential. This analysis uses both 97th percentile weather and 2010 Shultz Fire weather conditions to give both a worst case scenario and a scenario that has already occurred in the watershed around Flagstaff. For the analysis the 97th percentile weather conditions will only be used to show existing condition;

whereas, 2010 Schultz Fire weather conditions will be used for both existing conditions and alternative comparison.

Fire Hazard Ratings range from *extreme* to *low,* with *extreme* indicating that the area rated as such is in the highest danger of a worst case wildfire scenario. That is, the area rated as *extreme* will most likely experience high intensity fire if a wildfire were to start during hot, dry, and windy conditions. This type of fire would most likely be stand replacing and would create and/or result in fire effects outside the historical range of variability for ponderosa pine and mixed conifer ecosystems.

Fire Regime Condition Class (FRCC) can be a useful metric in determining the existing ecosystem health of a landscape as it relates to historic condition. This metric in its original form reflects the current vegetative structure, composition, and amount in relation to the departure of that structure, composition, and quantity from the natural range of variability for that area. FRCC includes measures of the departure from historic fire severity and frequency for a given landscape. The level of departure is attributable primarily to an increase in fire suppression and fire exclusion over the last 125 years and/or an increase in fire return intervals within the area (e.g. fires occur less frequently), thereby altering the ecological function of fire within that area. The lack of low intensity, high frequency fires in the forests of northern Arizona have led to forest conditions of higher fuel loadings and a larger number of trees per acre compared to the conditions that occurred historically. FRCC is a difficult metric to develop accurately using tools currently available. For most applications, FRCC is simplified to VCC (Vegetation Condition Class), which is a remote sensing product from LANDFIRE that gives a representation of the vegetation components of FRCC (LANDFIRE 2013). VCC can be used as a surrogate to FRCC, but does lack the departure from historic frequency and severity of fire that are included in the foundational formula of FRCC (Hann and Bunnell 2001). FRCC and VCC are discussed in more detail in the Methodology section.

Purpose and Need

The purpose of FWPP is to reduce the risk of high severity wildfire and subsequent high severity flooding in two key watersheds around the City of Flagstaff. Existing conditions within the project area include dense stands with numerous dog-hair thickets on steep slopes with high fire risk; with a substantial wildland urban interface (see Existing Conditions for more information).

To address the need for fuel reduction and in the process, help to restore and maintain ecosystem health in the Forest, as directed in the Coconino National Land Management Plan (1987, as amended; Forest Plan), there is a need to meet the following objectives of fuel treatments. These objectives have been formulated as guidelines for many current and potential projects that have a fuel reduction component, such as the Flagstaff Watershed Protection Project, and will be the measures by which each alternative is analyzed (see also the Methodology section).

1) Reduce the probability of crown fire initiation. This is achieved by accomplishing the following across the project areas.

a. Reducing the crown bulk density (the mass per volume of available canopy fuels).

b. Increasing the canopy base height (the height at which tree branches can be ignited by ground fire).

c. Reducing the potential flame length (the heat emitted by a ground fire).

2) Reduce the capability of the sites to sustain a crown fire. This is achieved by reducing the percent of canopy closure, in addition to those methods described above to reduce crown fire initiation.

3) Reduce the number of firebrands that could ignite spot fires. This can also be achieved by reducing the crown bulk density, by increasing the effective crown base height, and by reducing the expected flame length.

4) Reduce surface fuels; by reducing surface and canopy fuels the potential for spot fires is reduced by limiting the number of available receptors.

5) Reduce the distance at which firebrands would be expected to ignite spot fires by reducing the number of tree canopies that would burn simultaneously if ignited by surface fire. Reducing crown bulk density and canopy closure would meet this objective.

Treatments that are proposed to help reach these objectives would be expected to maintain these objectives for approximately 20 years by implementing periodic prescribed burning without executing additional thinning treatments.

Table 1 displays the wildfire occurrence over the last twenty years. Other than the Radio Fire (1977), which burned approximately 383 acres on Mt. Elden, the project areas have not experienced high severity fire or large fires in recorded history; therefore the 20 year time period was used as the best source of information relating to the project area.

Table 1: Wildfire Ignition Occurrence over the Past 20 years within FWPP

Past Wildfire Occurrence	**Human Caused**	**Lightning Caused**
Dry Lake Hills*	22 Fires (26.3 Acres)	40 Fires (83.2 Acres)
Mormon Mountain	4 Fires (0.5 Acres)	15 Fires (2.3 Acres)

*Wildfire Occurrence Analysis does not include the human caused Radio Fire (1977) that burned approximately 383 acres within the Dry Lake Hills Project Boundary

Overview of Issues Addressed

Comments related to fire, fuels and smoke emissions received during the scoping period on the proposed action are discussed here.

One commenter brought forth concerns that fuel treatments located on the National Forest, outside of private property, would not be effective in mitigating the fire risk component of the FWPP purpose and need, citing a study conducted by Cohen (2004).

While, extensive wildland vegetation management does not effectively change home ignitability, this should not imply that wildland vegetation management is without a purpose and should not occur for other reasons. However, it does imply the imperative to separate the problem of the wildland fire threat to homes from the problem of ecosystem sustainability due to changes in wildland fuels. For example, a WUI area could be a high priority for extensive vegetation management because of aesthetics, watershed, erosion, or other values, but not for reducing home ignitability (Cohen 1999).

Research Physical Scientist Jack Cohen noted after visiting homes that survived the Rodeo-Chediski Fire and those that were consumed, that had homeowners followed guidelines for creating defensible space—described as creating an area around a structure where fuels and vegetation are treated, cleared, or reduced to slow the spread of fire—more homes would have survived."

While Cohen's studies are helpful, they don't guarantee home protection. Cohen's findings document that clearing directly around housing (300 feet) is the most important action; in the rural setting, most homes include more land than in the urban setting, so treatment on that land is up to the landowner.

Additionally, the Flagstaff Watershed Protection Project not only seeks to protect private property, infrastructure and forest resources within and downstream from the project area from high-severity wildfire, but also from severe post-fire flooding. The large majority of scientific research regarding restoration in southwestern ponderosa pine ecosystem have identified tree thinning and prescribed burning as essential treatments to achieve restoration of biodiversity (Stoddard et al. 2011), development of large trees with old growth characteristics (Youngblood 2009, Shepperd et al,. 2001), mitigation of risk from high intensity wildfire (Fulé 2012), and protection of threatened and endangered species habitat (Dickson and Noon 2006, USFWS 1995, Kalies et al. 2010).

Treatments implemented as a part of any project on the National Forest would not fully remove the risk to homes during wildfire events, but they are likely to reduce the risk of a high severity fire, thus making suppression efforts more feasible. As stated by Cram, Baker & Boren, "The objective of fuel reduction in the wildland-urban interface or within a watershed cannot be to 'fire proof' the environment, but rather to reduce the likelihood of stand replacement crownfire, i.e., change the fire behavior," (2006).

Methodology & Assumptions Used in Analysis

A fire regime generally classifies the role of fire over the landscape in the absence of modern human mechanical intervention. There are five natural fire regimes, which are characterized based on average numbers of years between fires combined with fire severity of the dominant overstory vegetation. One can examine fire regimes at a finer scale in which each regime can be described at three different condition classes (I, II, III), also known as fire regime condition classes (FRCCS). Condition classes were created to characterize the importance of fire frequency in ecosystems. Fire regime condition class (FRCC) quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions due to an absence of fire and an increase in fire return intervals (Havelina et al. 2010). The deviation from the historic fire regime is measured according to the number of fire return intervals missed and the disturbance regime altered so as to alter current structure and composition of the system outside the normal range of variation (LANDFIRE 1.1.0).

For this analysis, fire regimes and FRCCs within the project were assessed using LANDFIRE. LANDFIRE uses vegetation condition class (VCC) as a surrogate to FRCC, but lack values in fire regime departure. The fire regimes for the project area include I, III, IV, and V and the condition classes range from level 1 to level 3. In general, if fire returns more than 100 years, most likely the fire will result in some stand replacement with the rest resulting in surface fire activity. Fire Regime I indicates that historical fires reoccur in less than a 35 year period, with fires resulting in a low percentage of overstory trees in the stand being replaced. Fires in a stand of fire regime III would generally reoccur every 35 to 200 years. Fire Regime IV indicates 35 to 200 year frequency, high replacement severity. Fire regime V indicates greater than 200 year frequency and severity.

The fuel moisture and weather characteristics used to model the effects and behavior of a potential wildfire for existing and desired conditions are conditions under 97th percentile and conditions observed on the Schultz fire on June 20th, 2010. The conditions used were as follows:

97th Percentile Conditions

- 1-hour fuel moisture: 2%
- 10-hour fuel moisture: 2%
- 100- hour fuel moisture: 4%
- 1000- hour fuel moisture: 7%
- 20-foot wind speed: 35 mph
- Air temperature: 85^{0}F

These weather conditions were used in modeling to give an overall worst case scenario in terms of crown fire potential. The 97th percentile conditions represent the top 3 percent worst fire weather days from 2002-2013.

Schultz Fire Conditions

- 1-hour fuel moisture: 3%
- 10-hour fuel moisture: 3%
- 100- hour fuel moisture: 6%
- 1000- hour fuel moisture: 11%
- 20-foot wind speed: 23 mph
- Air temperature: 74^{0}F

These weather conditions were used in modeling because the Schultz Fire was one of the biggest high intensity/stand replacing fires that has occurred most recently within fifteen miles of Flagstaff, Arizona and the fire resulted in a considerable amount of immediate damage and devastation to ecological resources and values at risk within the fire and to surrounding areas.

Weather conditions used in FVS/FFE for prescribed fire under all action alternatives are as followed. Weather conditions used are common for prescribed fire activity on the Flagstaff RD. However variables such as wind speed, air temperature, and moisture contents are on the upper end of prescriptions. Typically prescribed fire would be implemented under more moderate conditions; for analysis purposes this report analyzes higher end limits of prescribed fire conditions.

- 1-hour fuel moisture: 8%
- 10-hour fuel moisture:8%
- 100- hour fuel moisture: 10%
- 1000- hour fuel moisture: 15%
- 20-foot wind speed: 10 mph
- Air temperature: 80^{0}F
- Live fuel moisture: 110%
- Duff moisture content 50%

The objective of the modeling performed in this analysis is to:

1. Clarify potential effects of a wildfire burning under conditions similar to the Schultz fire and 97^{th} percentile weather conditions.
2. Identify areas where fire behavior may be problematic from the perspectives of both fire effects and control issues.
3. Analyze and evaluate the effects of the different alternatives.

The following metrics will be used to evaluate fire behavior and effects:

1) Fire Behavior (active/passive crown fire, surface fire, heat/unit/area*, and fireline intensity*):
   a) Crownfire:
      i) In ponderosa pine, white fir, doug fir, limber pine, and southwestern white pine, crownfire is lethal because they don't sprout. That makes it a good indicator of the severity of fire effects to the dominant vegetation (trees).
         Note: Fire is rarely lethal to Gambel oak or aspen, both of which will sprout when topkilled by fire. If they are topkilled, large and old trees would be replaced with sprouts and suckers.
      ii) It's a good indicator of where there may be control issues.
      iii) It's an easy-to-understand metric for comparison of some of the differences in effects between alternatives.

   b) Fireline intensity1 (fli: Btu/time/length):
      i) Represents the energy released per line (distance) of the flaming front, covering the front to the back of the flaming combustion zone. There is a good correlation between flame length and fire line intensity.

   c) Heat per unit area1 (hua; Btu/time/area):
      i) Represents the energy released per area during the flaming combustion stage of fire. It does not include energy released during the smoldering combustion stage (thus, the addition of surface fuel loading to this analysis).

For any given fireline intensity (flame length), the faster the rate of spread, the less heat will be directed to the site. Conversely, a slow-moving fire with the same fireline intensity as a fast-moving fire will concentrate considerable heat on the site (Rothermel and Deeming 1980). The character of the two fires is, however, very different. A fire in short grass is fast spreading with a low heat per unit area, and a fire in timber litter and understory is also slow spreading, but has a high heat per unit area. While the fireline intensity may be nearly identical for these two examples, there can be a large difference in heat per unit area because of the much faster rate of spread in the grass, which produces much less heat at any given point on the ground (Andrews et al. 2011).

2) Arrival time:

[1] **These are being modeled for use with geoWEPP and the watershed study being conducted by RMRS (Moscow, ID), and will not be used by themselves to compare alternatives in the EIS.**

a) This metric shows where fire is likely to burn in a given amount of time given a specific ignition location. As modeled in FlamMap, it's a metric with which to compare differences between alternatives.
b) There is no way to know with any certainty where a wildfire would start, so three separate ignition point sources were used. Areas used in modeling were identified by district Fuels Specialist based off values at risk, such as urban interface concerns, watershed values and recreational activities that occur in the project area. The three areas in the DLH and the one location on MM will be identified on the Arrival time map Appendix 3.

3) Emissions
   a) Particulate matter of 2.5 microns or less (PM 2.5) is addressed in the Clean Air Act and has a NAAQS annual mean of 15µg/m3, and a 24 hour average of 35µg/m3. Although modeling total potential outputs, it is important to note that it is not the total amount of emissions from a fire that affect human health, but rather how concentrated pollutants in ambient air are for a period of time. PM 2.5 emission amount under a wildfire scenario are estimated using FVS per alternative.

4) Fire Hazard Ratings were calculated for existing and desired conditions of stands within the Flagstaff Watershed Protection areas. Stand Exam data was collected in approximately 50 percent of the Dry Lake Hills project area and 93 percent in the Mormon Mountain project area. Fire hazard ratings measure how intense and virulent a fire would burn under 97th percentile weather conditions during April through July. The field data collected to calculate existing fire hazard ratings in the project area include dead and down fuel loading (tons per acre), number of tree stems per acre, tree diameter, percent canopy closure, height to bottom of live crown (crown base height), and tree height. Slope and aspect also affect fire hazard ratings and therefore were acquired for stands in the project area using 10 Meter Digital Elevation Models.

5) Crown fire potential (pre and post treatment) was assessed using FlamMap 5.0 modeling, including LANDFIRE data GIS. The data layer is a representation of the type of fire that would be burning at any given location in the project area within two scenarios: 1) Weather conditions at the 97^{th} percentile to represent the "worst case" scenario, prevailing winds being out of the southwest, and sustained winds at 35mph, and 2) Schultz Fire 2010 weather conditions to represent an existing scenario, prevailing winds being out of the southwest at 23mph. Actual number of acres analyzed may differ from the proposed action acreage due to modeling outputs and pixel calculations.

6) Flame Length, Stand Conditions (trees per acre, crown base height, crown bulk density, and down woody debris), and Predicted PM 2.5 smoke emission under a wildfire scenario were calculated using the Fire and Fuels Extension within the Rocky Mountain variant of the Forest Vegetation Simulator (FVS) for silviculture stand data for both existing and post treatment conditions. FVS was used to model proposed treatments and determine the effects of these treatments (thinning treatments only) on the fuel characteristics of and potential fire

behavior under severe fire conditions within proposed treatment areas within the project areas. Dead and down woody material data was collected in the field by both a contractor crew and the Flagstaff Ranger District fuels/silviculture crew, and modeled based on treatments identified in each alternative. Stand exam data including dead and down woody debris data was collected using FSVeg protocols in approximately fifty percent of the DLH area and ninety three percent in the MMM area. No surveying and stand exam data collection occurred in the remaining fifty percent of the DLH and seven percent in the MM project area. Severe fire conditions modeled in FVS utilizing 97th percentile weather conditions, and fire conditions modeled under 2010 Schultz Fire weather conditions. Exact weather parameters are listed under the Existing Conditions portion of this report. Flame Lengths were modeled for both a post treatments wildfire scenario (surface + crown fuels) and flame lengths during prescribed fire (surface fuels). Canopy cover was calculated differently than the base FVS model. To better account for local conditions that affect canopy cover, a formula derived from research completed in the area was used. (-57.44+25.5047*LN(BA)). This formula incorporates basal area (BA) calculated from FVS as a basis in the linear function for this formula. This formula also mirrors the formula used for the timber specialist report. For more details on exact FVS inputs used refer to Appendix 3.

7) Fire regimes and condition classes were also used to help describe the existing ecological health and condition of the project area in relation to the historical role of fire in the Flagstaff Watershed Project areas. As discussed in the existing condition section. A fire regime generally classifies the role of fire over the landscape in the absence of modern human mechanical intervention. There are five natural fire regimes and are characterized based on average numbers of years between fires combined with fire severity of the dominant overstory vegetation. One can examine fire regimes at a finer scale in which each regime can be described at three different condition classes (I, II, III), also known as fire regime condition classes (FRCCs). Condition classes were created to characterize the importance of fire frequency in ecosystems. FRCC quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions due to an absence of fire and an increase in fire return intervals ((http://www.landfire.gov/NationalProductDescriptions11.php). The deviation from the historic fire regime is measured according to the number of fire return intervals missed and the disturbance regime altered so as to alter current structure and composition of the system outside the normal range of variation (Havlina et al. 2010).

For this analysis, Vegetation Condition Class (VCC) was used as a surrogate to FRCC. Due to issues relating to the difficulty and inaccuracy of developing actual FRCC ratings with tools available, VCC data was pulled from LANDFIREs 1.0.0 data set. This data set gives a course assessment of vegetative conditions as it relates to ecosystem process and functions, but is lacking the fire regime departure components (fire frequency and severity) that are required to make a full FRCC assessment based on the 2001 FRCC concept by Hann and Bunnel.

Fire and Fuels

Existing Condition

The Flagstaff Watershed Protection Project consists of approximately 10,543 acres in two locations: the Dry Lake Hills (DLH) portion, which is approximately 7,569 acres, and the Mormon Mountain (MM) site, which is approximately 2,974 acres. Both sites are composed of stands of predominantly ponderosa pine and mixed conifer with an understory of needle litter, grass, and some shrub according to LANDFIRE fuel model data. Fire behavior fuel model descriptions are outlined and described in Scott and Burgan (2005). The number and acres of fuel models located within the project area differ from the number and acres of fuel models for existing conditions due to available stand exam data. The fire behavior fuel models for each area within the FWPP are listed in Table 2 and Table 3 below. NOTE: All LANDFIRE 1.1.0 fuel models that did not represent more the 1 percent of the analysis area were removed from analysis.

Table 2: Fire behavior fuel models for Dry Lake Hills.

Category	Code	Acres (%)
low load grass	GR2 (102)	250 ac. 3%
moderate load grass-shrub	GS2 (122)	957ac. 13%
moderate load dry climate shrub	SH2 (142)	96 ac. 1%
low load timber, grass, shrub	TU1 (161)	911ac. 12%
very high load timber, shrub	TU5 (165)	1,469ac. 20%
high load conifer litter	TL5 (185)	32ac. <1%
High load long needle litter	TL8 (188)	3,789ac. 50%

Table 3: Fire behavior fuel models for Mormon Mountain.

Category	Code	Acres (%)
low load grass	GR2 (102)	7 ac. <1%
moderate load grass-shrub	GS2 (122)	254 ac. 9%
moderate load dry climate shrub	SH2 (142)	5 ac. <1%
low load timber, grass, shrub	TU1 (161)	83 ac. 3%
very high load timber, shrub	TU5 (165)	1,876 ac. 14%
high load conifer litter	TL5 (185)	4 ac. <1%
High load long needle litter	TL8 (188)	2,198 ac. 74%

Model descriptions are used to characterize the fuel complex, fuel loading, fuel bed depth, and moisture of extinction (upper limit of fuel moisture beyond which a fire will no longer spread with a uniform front) of an area (Graham et al. 1999). Models help further characterize surface fire behavior and predict fire spread rate and fire intensity (flame length) when dead and live fuel moistures, slopes, and wind speeds are known.

The following vegetation types occur in the Dry Lake Hills project area include ponderosa pine, Douglas-fir, white fir, mixed conifer, oak woodland, aspen and grasslands; vegetation types in the Mormon Mountain project area include ponderosa pine, mixed conifer and wet mixed conifer.

<u>DLH</u>

- Ponderosa pine- 4,059 acres
- Mixed conifer- 3,118 acres
- Pine /Oak woodland- 277 acres

- Aspen- 22 acres
- Grassland- 60 acres
- Right of way – 33 acres

Mormon Mountain

- Ponderosa pine- 1,924 acres
- Mixed conifer- 838 acres
- Wet mixed conifer – 213

Fire hazard ratings were calculated for existing and desired conditions for 50 percent of the DLH and 93 percent in the MM project areas, commensurate with the area in which field data was collected in each portion of the total project area. Fire hazard ratings measure how intense and virulent a fire would burn under hot, dry, and windy conditions during April through July. The field data collected to calculate existing fire hazard ratings in the project area include dead and down fuel loading (tons per acre), number of tree stems per acre, tree diameter, percent canopy closure, height to bottom of live crown (crown base height), and tree height. Slope and aspect also affect fire hazard ratings and therefore were acquired for stands in the project area using the Coconino 10 Meter Digital Elevation Models.

The fire hazard ratings and the corresponding acreages for the percentage of land surveyed in the DLH and MM project areas as analyzed are as follows:

Based on the 3,837 acres (50%) surveyed the fire hazard ratings and the corresponding acreages for the Dry Lake Hills project area are as follows:

Extreme- 2,582 acres
Very High- 72 acres
High- 613 acres
Moderate-470 acres
Low- 100 acres

Based on the 2,784 acres (93%) surveyed the fire hazard ratings and the corresponding acreages for the Mormon Mountain project area are as follows:

Extreme- 2089 acres
Very High- 197 acres
High- 273 acres
Moderate-174 acres
Low- 51 acres

The numbers above are a conservative estimate based on the areas that received stand exams. Because of the lack of fire within both project areas and knowledge of adjacent stand conditions, it is likely that the remaining unsurveyed acres would also be in the *high* to *extreme* rating. *Extreme* fire hazard ratings in the project areas were contributed to high fuel loading, low crown base heights, a large number of trees per acre, and/or large percentages for canopy closure.

A fire regime is a set of recurring fire conditions that characterize an ecosystem, within a historic, natural or human induced context. This set of recurring conditions may include the following: seasonality, frequency (fire return interval), intensity, severity, size, spatial complexity, and fire type. An accurate description of a fire regime will include the full range of fire events, including those that are rare and connect to the larger disturbance regime which contains the fire regime as a subset (Sugihara et al. 2006). FRCC is described in detail under Methodology (Page 4).

Table 4 Condition Class definitions used for FRCC.

	Departure from historic Fire Regime
Condition Class 1	Fire regimes are within historical ranges. Risk of losing key ecosystem components is low. Vegetation attributes are intact and functioning within historical ranges.
Condition Class 2	Fire regimes moderately altered from historical range. Risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical ranges by one or more return intervals. This has resulted in moderate changes to one or more of the following: fire size, intensity, severity, and/or landscape patterns. Vegetation attributes have been moderately altered from their historical range.
Condition Class 3	Fire regimes significantly altered from historical ranges. Risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals resulting in dramatic alterations to: fire size, intensity, severity, and landscape patterns, and/or vegetation attributes.

For this analyses fire regimes and FRCCs within the project were assessed using LANDFIRE. LANDFIRE uses vegetation condition class (VCC) as a surrogate to FRCC, but lack values in fire regime departure. All five fire regimes and all three VCCs are represented in the project area.

Table 5 Historic Fire Regime Groups and Descriptions

Fire Regime	Frequency	Severity	Severity Description	Vegetation types that would be affected by treatments proposed under the FWPP
I	0 – 35 years	Low/ mixed	Mostly low severity replaces less than 25% of dominant overstory vegetation. May include mixed-severity fires that replace up to 75%	In pure ponderosa pine, pine/oak, and savanna ponderosa pine is the dominant species, so the severity of a burn is related to the fire effects on the pine.
II	0 – 35 years	Replacement	High severity replaces greater than 75 % of dominant overstory (grasslands).	Grasslands. The herbaceous layer (grasses and forbs) are the dominant species. Greater than 75 percent of these are generally topkilled by a fire, so it is considered high severity.
III	35 - 100 years	Mixed/ low	Generally mixed-severity; may also include low severity fires.	Mixed conifer falls into this category.
IV	35 - 100 years	Replacement	High severity.	Wet Mixed Conifer and Aspen often falls into this category.
V	100+ years	Replacement/any severity	Any severity may be included, but mostly replacement severity; may include any severity with this frequency	Much of the Piñon/Juniper (PJ) falls into this category, though there are different types of PJ systems and the fire return intervals vary.

Table 6 displays the acres for each Fire Regime and condition class (VCC) found in the Dry lake Hills Project area. Table 7 displays the acres for each Fire Regime and condition class found in the Mormon Mountain area.

Table 6 Dry Lake Hills Summary Fire Regime and Condition Class Acres

Fire Regime I: Frequent Fires (0-35 years), surface to mixed burn severity		
Condition Class 1- low vegetation departure	Condition Class Level 2- moderate vegetation departure	Condition Class Level 3- high vegetation departure
6 ac. <1%%	644 ac. 12%	4,783 ac. 88%
Fire Regime III: 35 to 200 year frequency, low to mixed burn severity		
Condition Class Level 1	Condition Class Level 2	Condition Class Level 3
<1 ac. 0%	325 ac. 18%	1487 ac. 82%
Fire Regime IV: 35 to 200 year frequency, high replacement severity		
Condition Class Level 1	Condition Class Level 2	Condition Class Level 3
<1 ac. 0%	81 ac. 40%	123 ac 60%
Fire Regime V: > 200 year frequency, any severity		
Barren	Condition Class Level 2	Condition Class Level 3
<1 ac.2%	28 ac. 72%	10 ac. 26%

The data from DLH shows that 4,783 acres or 88 percent of the project is in Fire Regime I, Condition Class Level 3 and 1,487 acres in Fire Regime III Condition Class Level 3. The high vegetation departure is due to the fire return interval in the area being greater than the historical fire return interval.

Table 7 Mormon Mountain Summary Fire Regime and Condition Class Acres

Fire Regime I: Frequent Fires (0-35 years), surface to mixed burn severity		
Condition Class 1- low vegetation departure	Condition Class Level 2- moderate vegetation departure	Condition Class Level 3- high vegetation departure
<1 ac. 0%	58 ac. 2%	2,646 ac. 89%

Fire Regime III: 35 to 200 year frequency, low to mixed burn severity		
Condition Class Level 1	Condition Class Level 2	Condition Class Level 3
0 ac. 0%	117 ac. 4%	144 ac. 5%

The differences between the current conditions and reference conditions has created existing conditions in both project areas favoring wildfire activity, if started, that would result in more severe effects to ecosystem components than should occur under the natural fire regime. The introduction of thinning and prescribed fire would improve the VCC rating for those areas that deviate from the historical fire regime.

The deviation between the current and historical intervals has created existing conditions in both project areas favoring wildfire activity, if started, that would result in more severe effects to ecosystem components than should occur for the natural fire regime.

Table 8 and Table 9 describe the existing conditions based off stand data and modeling outputs for canopy base height, dead and down (tons/acre), canopy bulk density, percent canopy closure, stems per acre, flame lengths (wildfire scenario, includes surface and canopy fuels) and potential emissions from smoke (wildfire conditions). The existing conditions modeling outputs may differ from the silviculture report due to differences in averaging outcomes (trees per acre and canopy cover).

Table 8: Existing Conditions for DLH project area (2013)

Existing Conditions (2013)	Canopy Base Height (ft.)	Dead and Downed Fuel (tons/acre) [avg]	Canopy Bulk Density (kg/M^3)	Canopy Closure (%)	Stems (Trees) per Acre	Potential Wildfire Scenario Flame Length (ft.) (surface+canopy fuels)	Potential Smoke Emission (PM2.5) (lbs./tons consumed)
Goshawk Nest Stands	3.0	6.2	0.07	70.6	594	75.1	0.10
MSO Nest Stands	6.5	29.1	0.19	63.8	1951	98.2	0.21
MSO Nest Roost Recovery Stands	2.6	58	0.25	69.6	2583	132.9	0.38
MSO PAC Stands	10.8	21	0.11	68.4	650	82.8	0.17
Ponderosa Pine (Goshawk Foraging and PFA outside MSO)	14.6	7.4	0.07	66.1	260	56.7	0.12
Schultz MSO Nest Stands	6.5	29	0.19	66.8	1952	98.2	0.21

Table 9 Existing Conditions for MM project area (2013)

Existing Conditions (2013)	Canopy Base Height (ft)	Dead and Downed Fuel (tons/acre) [avg]	Canopy Bulk Density (kg/M^3)	Canopy Closure (%)	Stems (Trees) per Acre	Potential Wildfire Scenario Flame Length (ft.) (surface+canopy fuels)	Potential Smoke Emission (PM2.5) (lbs./tons consumed)
*Mixed Conifer	10	40	0.20	64	1164	59	0.41
Ponderosa Pine	9	13	0.09	69	1281	52	0.20
*Includes wet and dry mixed conifer to include MSO Pac and Nest Cores							

Measurements of existing height to live crown, dead and down fuel (tons per acre), percent canopy closure, fuel type, and stems per acre were collected during stand exams, and fire regime condition classes and fuel modes were calculated using LANDFIRE and FVS. Flame lengths produced under existing conditions were determined using the FFE (Fire and Fuels) Extension in FVS, modeled under 97th percentile conditions. As mentioned, the fuel moisture and weather characteristics used to model the effects and behavior of a potential wildfire for existing and desired conditions are conditions under 97th percentile and conditions observed on the Schultz fire on June 20th, 2010 (see the Methodology section for more information).

According to the modeling outcome, flame lengths under existing conditions for the majority of both project areas would exceed 4 feet. Flame lengths greater than 4 feet usually require these fires to be initially attacked using mechanical equipment such as dozers or aerial resources such as helicopters and air tankers. Modification of existing conditions that would lower potential flame lengths to approximately 4 feet if a wildfire occurred would make it more feasible for initial attack forces to control such a wildfire starting under 97th percentile and Schultz fire weather conditions.

Modeling also showed that other forest characteristics contribute to creating severe fire effects and behavior in the project areas if a wildfire was to start under dry, hot, and windy weather conditions. Canopy closures greater than 50 percent and low crown base heights (less than about twenty feet) contribute to considerable tree torching, spotting as much as a mile ahead of an intense surface fire and in some cases, crown fire spread. These fire behavior conditions would inevitably create a fire situation in which fire spread would be difficult to attack and control with ground forces within one operational shift (typically 12 hours).

Crown fire potential was also analyzed for both project areas using data generated from modeling performed using FlamMap 5.0. Three types of fires result from the modeling. Surface fire describes fire that burns through the surface fuels of the forest floor. This type of fire has the least active of fire behaviors and is the most beneficial of the three types of fires in maintaining the historical, ecological role of low intensity, high frequency fire in the southwestern ponderosa pine ecosystem. Passive crown fire, or torching, occurs when flame lengths are long enough to reach the lower edge of the canopy and can result in individual or small group tree torching but does not proliferate through the forest canopy through continuous crown fire spread. Active crown fire occurs when flames reach the forest canopy and spreads through it with intensity and continuity.

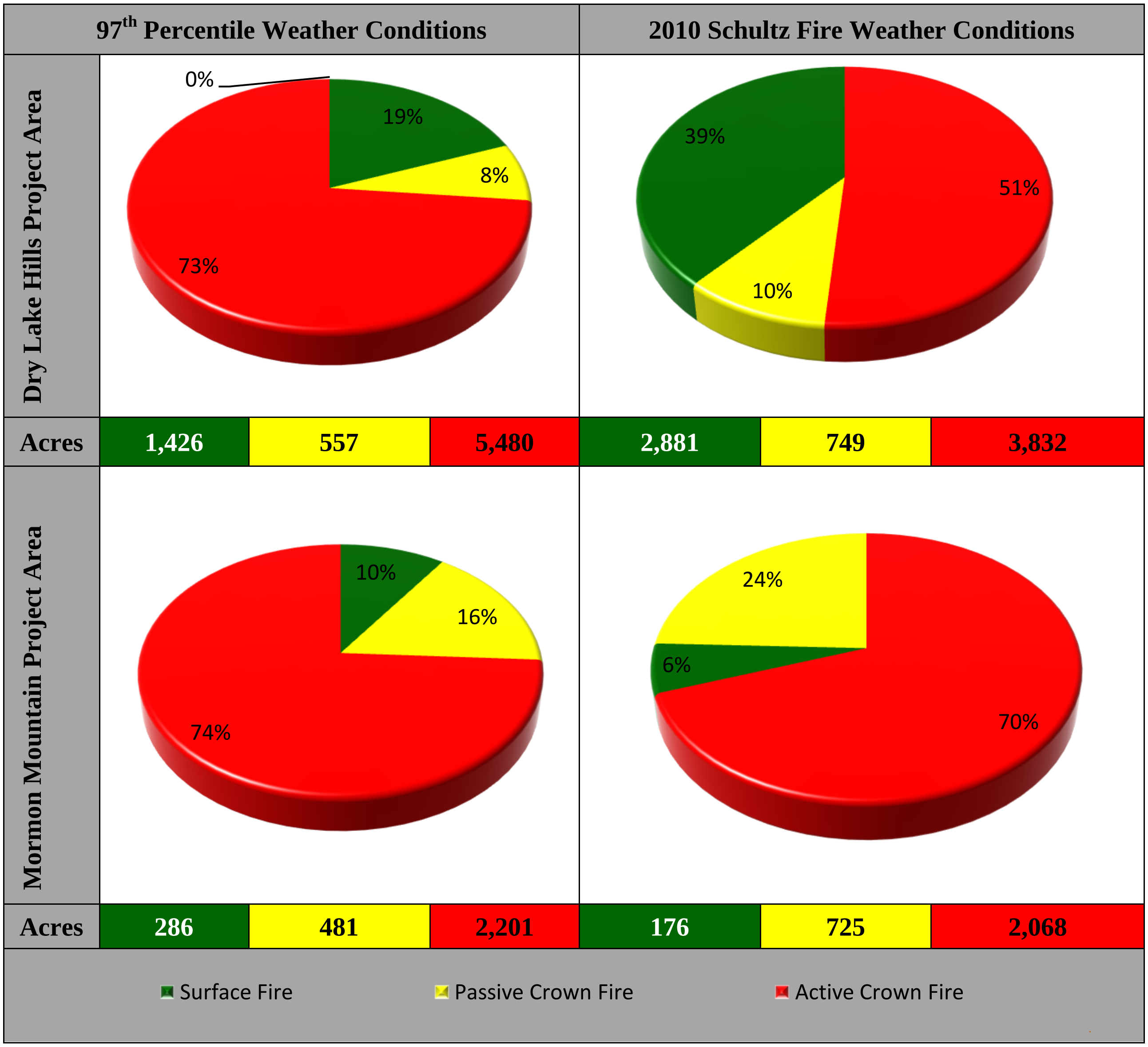
Modeling crown fire potential in the DLH area under both 97th percentile and Schultz fire conditions are shown in Figure 1.

Under 97th percentile conditions, 73 percent of the area would experience active crown fire, 8 percent passive crown fire and 19 percent surface fire. Under Schultz conditions, modeling shows 51 percent of the area would experience active crown fire, 10 percent passive crown fire and 39 percent surface fire behavior.

Modeling crown fire potential within the MM area under the same parameters is as follows: 97th percentile equates to 74 percent active crown fire, 16 percent passive and 10 percent surface. Schultz conditions would be70 percent active crown fire, 24 percent passive crown fire and 6 percent surface fire.

Existing Condition Crown Fire Potential maps are shown in Appendix 2.

Figure 1: Crown Fire Potential under 2010 Schultz Wildfire and 97th Percentile Weather Conditions for Dry Lake Hills and Mormon Mountain



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Arrival Time

This metric shows where fire is likely to burn in a given amount of time given a specific ignition location. As modeled in FlamMap, it's a metric with which to compare differences between alternatives. There is no way to know with any certainty where a wildfire would start, so three separate ignition point sources were used in the DLH area and one ignition source on the MM area. Areas used in modeling were identified by the District Fuels Specialist based on values at risk, such as urban interface concerns, watershed values and recreational activities that occur in the project areas. Modeling parameters included Schultz fire weather conditions. Ignition source locations used in the DLH area for modeling were:

1.) The intersection of Forest road (FR) 420 and 557 (the Y)
2.) The intersection of FR 557 and Lower Oldham Trail.
3.) At the National Forest boundary north of Paradise Street.

The modeling ignition location on MM was placed on along FR 648 (Mormon Mountain Tower Road).

The Table 10 displays the estimated arrival time of the modeled fires in hours. For example, if a fire were to start at the Intersection of FR 420 and FR 557 (the Y). Under modeled conditions the fire would burn approximately 51acres in the first hour and 2,803 within the first 5 hours.

Table 10: Arrival time in acres/hour Existing Condition

Arrival Time	Intersection of FR 420 and 557	Intersection of FR 557 and Oldham Trail	Paradise	FR 648 (Mormon Mountain)
1st Hour	51	469	259	197
2nd Hour	318	1411	1217	607
3rd Hour	960	2414	2012	1003
4th Hour	1604	3482	2773	1614
5th Hour	2803	4156	3438	2508

Arrival time and ignition locations are identified in Appendix 3.

Table 11 displays the wildfire occurrence over the last twenty years. Other than the Radio Fire (1977), which burned approximately 383 acres on Mt. Elden, the project areas have not experienced high severity fire or large fires in recorded history; therefore the 20 year time period was used as the best source of information relating to the project area.

Table 11: Wildfire Ignition Occurrence over the Past 20 years within FWPP

Past Wildfire Occurrence	Human Caused	Lightning Caused
Dry Lake Hills*	22 Fires (26.3 Acres)	40 Fires (83.2 Acres)
Mormon Mountain	4 Fires (0.5 Acres)	15 Fires (2.3 Acres)

*Wildfire Occurrence Analysis does not include the human caused Radio Fire (1977) that burned approximately 383 acres within the Dry Lake Hills Project Boundary

Environmental Consequences

General Effects of Thinning and Prescribed Burning

There are many components that influence fire behavior. In order to address how to change the influence of these components on fire behavior within a stand and/or over a landscape, an explanation of how thinning and burning activities can affect these different components and thereby fire behavior has been provided here.

Dead and down fuel loading directly effects flame length and duration. A large amount of dead and down fuel on the ground produces longer flame lengths for a longer period of time during hot, dry conditions as compared to a low amount of dead and down surface fuel loading. Longer flame lengths and burning durations also increase the risk or potential for fire to transition into the crown or forest canopy, especially if crown base heights within the stand are low.

Periodic prescribed burning can reduce expected flame lengths by burning surface fuels initially and then maintaining a low dead and down fuel loading in subsequent burns. For prescribed fire to be effective and safe within the project area, canopy closures would need to be reduced in advance of burning. Therefore, thinning stands before burning helps create a safer environment in which to implement prescribed fire. Decreasing canopy closure and crown bulk density can increase the canopy base height if many small trees exist in the understory and the majority of those small understory trees are cut.

The height to the bottom of live crown (crown base height) directly affects how easily a fire torches trees, producing firebrands, and how easily a fire transitions into a crown fire. The number of tree stems per acre also affects how easily a fire is able to transition into a crown fire by not providing the fire with burnable material, but also allowing heat to accumulate more easily under the canopy. Thinning from below increases height to bottom of live crown, decreases the number of stems per acre, opens up the canopy, and allows heat created by burning surface fuels to be dispersed more readily. All of these actions reduce the ease with which a fire can “torch” trees and/or transition to a crown fire and produce firebrands that create/ignite spot fires.

Lastly, by both thinning and burning, stands can reach conditions that are closer to the natural historic fire regime of vegetation characteristics, fuel composition, fire frequency, severity, and pattern. This can be achieved by thinning and prescribed burning at appropriate burn intervals. The combination of thinning and then prescribed burning in intervals should help stands that currently have FRCC/VCCs of three and fire hazard ratings of *extreme* to *high* to reach FRCC/VCCs of one or two and fire hazard ratings of *moderate* to *low* over time.

Alternative 1 – No Action

Direct & Indirect Effects

Ground Fuels and vegetation

No fuel reduction and no change in vegetative structure of the forest within the FWPP area would occur under the No Action Alternative, with the exception of the areas that could be implemented under the Jack Smith Schultz and Eastside project decisions. This alternative would not reduce the existing fire hazard within the project area. Not implementing fuel treatments including thinning and prescribed burning would encourage unhealthy ecosystem conditions to persist. These conditions would persist because fuel loading would continue to accumulate on the forest floor without the reduction of these fuels by low intensity, high frequency fires mimicked by periodic prescribed burning consisting of three to seven year burn intervals. Also without thinning, the number of trees per acre would continue to rise both in the forest and in areas that were historically grasslands/meadows.

Without periodic prescribed burning, crown base heights would also continue to remain low. As more trees grow within the project area, low crown base heights result in more crown ladder fuels and with them, in addition to greater crown bulk densities, an increased potential/risk for passive and active crown fires to occur within the forested stands of the project area during hot, dry weather conditions.

High intensity, stand replacing fire would initially reduce the dead and down fuel within the project area, but it would do so at the cost of negatively altering existing ecosystem condition and diversity (vegetation, wildlife, soils, watershed, etc) and damaging heritage resource sites. Also, as time goes by, more dead and down woody fuel would increase, potentially increasing fire hazard over time as dead trees and other dead fuels produced in the stand replacing fire fall to the forest floor (Greenlee and Greenlee 2002).

Fire Suppression Efforts

Under this alternative a wildfire would likely produce flame lengths in excess of four feet (Table 8 and Table 9). Initial attack of these fires would usually require using mechanical equipment such as dozers or aerial resources such as helicopters and air tankers. If a wildfire occurred under this alternative, it would be difficult for initial attack forces to control in the first operational period.

Wildfire Hazard Potential

Another effect of the no action alternative would be the increased potential for a wildfire to become established and burn with sufficient intensity to exceed the capability of emergency response personnel. Wildfires in the wild-land/urban interface place particularly high demands on emergency response personnel, and such a fire would threaten multiple structures and multiple groups of people in a very short span of time. Firefighting resources are deployed when human life is immediately at risk or there is a clear emergency, thus leaving fewer personnel to actually bring the fire under control. This generally results in larger wildfires and greater resource damage to the national forest.

Most of the area surrounding the project area provide several popular recreational opportunities for the forest visitor, such as camping, hiking, scenic viewing, hunting, and riding ATV and/or UTVs and is highly visited throughout the year although more so during the summer and fall months. Recreationists tend to build campfires during their stay in the forest; some fires are started in established campfire rings and others in temporary campfire rings. Many times these fires are left unattended or do not get properly extinguished and escape from the ring. Prevailing winds during the year are mostly out of the southwest. If a campfire escapes in or near the project area during hot, dry, windy weather conditions, this escaped fire could pose a threat to the FWPP project areas. The No Action Alternative would not include a permanent campfire closure order for the DLH portion, and also would not decommission any closed Forest Roads; thereby campfires and illegal public access could still occur, and the threat of human-caused fires would remain.

Finally, Alternative 1 leaves much of the area in extreme and very high fire danger as well as Condition Class III (a severe departure from the natural historical regime of vegetation characteristics, fuel composition, fire frequency, severity and pattern). As time passes, even more area would transition to a Condition Class III and further result in destructive wildfires more severe than the area’s historic fire regime.

Table 12 and Table 13 represent the existing conditions and anticipated conditions in twenty years under the No Action Alternative.

Table 12: Dry Lake Hills average projected conditions under the No Action Alternative

Alt. 1 Projected Conditions Dry Lake Hills *(No Action)* **No Treatment 2017** **No Treatment 2033**	**Canopy Base Height (ft)**	**Dead and Downed Fuel (tons/acre) [avg]**	**Canopy Bulk Density (kg/M^3)**	**Canopy Closure (%)**	**Stems (Trees) per Acre**	**Potential Wildfire Flame Length (ft)**	**Potential Wildfire Smoke Emission (PM2.5) (lbs/tons consumed)**
Goshawk Habitat (2017)	3	7	0.07	71	583	14	0.14
Goshawk Habitat (2033)	4	10	0.08	74	534	20	0.17
MSO PAC Habitat (2017)	12	19	0.10	69	610	39	0.20
MSO PAC Habitat (2033)	13	21	0.12	71	543	37	0.23
MSO Nest Core (2017)	8	22	0.11	57	546	33	0.20
MSO Nest Core (2033)	9	28	0.15	67	516	49	0.22
Nest Roost Habitat (2017)	3	58	0.24	70	2947	86	0.40
Nest Roost Habitat (2033)	3	58	0.25	73	2386	93	0.46
Ponderosa Pine (2017)	16	8	0.7	67	254	10	0.11
Ponderosa Pine (2033)	18	10	0.7	69	231	10	0.12

Table 13: Mormon Mountain average no action alternative projected conditions

Alt. 1 Projected Conditions Mormon Mountain (No Action) / No Treatment 2017 / No Treatment 2033	Canopy Base Height (ft)	Dead and Downed Fuel (tons/acre) [avg]	Canopy Bulk Density (kg/M^3)	Canopy Closure (%)	Stems (Trees) per Acre	Potential Wildfire Flame Length (ft)	Potential Wildfire Smoke Emission (PM2.5) (lbs/tons consumed)
*Mixed Conifer (2017)	9	40	0.2	64	1153	62	0.43
*Mixed Conifer (2033)	10	45	0.19	71	975	69	0.49
Ponderosa Pine (2017)	8	14	0.9	61	1198	55	0.16
Ponderosa Pine (2033)	11	17	0.11	69	919	57	0.18
*Includes wet and dry mixed conifer, to include MSO PAC's and Nest Cores							

Under the No Action Alternative, a wildfire would produce flame lengths exceeding 4 feet, making it difficult and unsafe for initial attack crews to control a wildfire occurring under modeled conditions. The average surface flame lengths under Schultz Fire weather conditions commonly range from 10 to 93 ft. (including canopy fuels) over all treatment areas. When looking at existing conditions of stands according to fuel model distinction, many areas have flame lengths that could potentially reach more than 50+ feet (including canopy fuels). These averages seem to be consistent considering many individual stands within treatment areas consist of as much as 10 to 60 tons per acre of down and dead woody debris. Furthermore, canopy closure exceeds 60 percent in many stands and canopy bulk density is well above .02(kg/M^3) in most stands.

Cumulative Effects

The cumulative effects boundary for this project is the Flagstaff Ranger District, as this encompasses most of the forested land subject to the prevailing winds driving a wildfire into the community of Flagstaff and the surrounding areas. The project areas (DLH and MM) are within the Flagstaff Community Wildfire Protection Plan area (CWPP) the treatments proposed are in line with the goals and objectives set forth by the CWPP.

The time period analyzed for the cumulative fire effects of this project includes a twenty year period from 2013 to 2033. Prior to that time the only activities in the area that affected the fire hazard were aggressive fire suppression and the continuing growth of forest vegetation.

Implementation of the No Action Alternative, along with past, present, and reasonably foreseeable actions, may have cumulative effects relative to fire and fuel conditions within the project area.

When combined with the effects of climate change, a cumulative effect of the No Action Alternative would be an increase in the number of acres of national forest that are vulnerable to severe fire effects. The vegetation type across the Coconino National Forest requires periodic fire to remain balanced. Fuel conditions have reached a point where fire effects are more severe than desired and more severe than would naturally occur. The fire hazard and fuel profile increases with time as the vegetation grows and dies.

Another cumulative effect of the no action alternative increases the possibility that a wildfire can get established and burn with sufficient intensity to exceed the capability of emergency response personnel. Wildfires in the wildland urban interface (WUI) place particularly high demands on emergency response personnel. WUI wildfires may threaten multiple structures and multiple groups of people in a very short span of time. Firefighting resources are deployed when human life is immediately at risk or there is a clear emergency, thus leaving fewer personnel to actually serve as suppression resources that can control the fire. The reduction in the suppression workforce during human safety emergencies generally results in larger wildfires and greater resource damage to the national forest.

Direct and Indirect Effects Common to Alternatives 2 & 3

Alternative 2 and 3 have similar desired outcomes with slight differences in harvesting methods. Effects to ground fuels and vegetation, fire suppression efforts, and wildfire hazard potential (not including canopy fire potential and anticipated prescribed fire effects) are the same between the two alternatives, and are discussed here. Those differences in effects are discussed separately under each alternative.

Ground Fuels and Vegetation

Direct effects of Alternatives 2 and 3 would be consistent with other similar fuels treatment projects on the Flagstaff Ranger District: prescribed fire would reduce surface fuels, raise crown base heights, reduce stems per acre and improve stand conditions. Initial entry and maintenance prescribed fire may also result in an increase in mortality and reduce the amount of available logs and snags. However, with the anticipated mortality associated with prescribed burning (Table 14 and Table 15), snags and logs would be created to offset the direct effect.

Fire Suppression Efforts

Fuel reduction treatments within the wildland urban interface should reduce expected fire behavior to a level at which a small number of personnel can quickly and effectively control a wildfire. The objectives of the treatments are to reduce the possibility that wildfires can get established and reduce the intensity with which wildfires can burn. These reductions further reduce the probability that the demand on emergency response personnel would be exceeded and reduce the threat to life and private property. Wildfires can be controlled with fewer acres burned resulting in less damage to National Forest lands. Also, wildfires burn less severely resulting in less resource damage to each acre burned.

Wildfire Hazard Potential

Alternatives two and three would result in short-term increases in wildfire hazard potential while treatments are occurring due to dead trees and slash being produced on site. While the proposed thinning reduces crown fire ladders, canopy closure, and crown loading, the majority of the slash produced would be piled on site, temporarily increasing the dead and down fuel loading until the piles are burned within prescription. Slash treatments under the alternatives would possibly include whole tree harvesting, which consists of all woody debris being removed from the forest and therefore reducing the need for pile burning. If available, biomass utilization would also remove slash and debris from the forest, thus negating the need for pile burning. However, under all slash-removal options, broadcast burning would still occur prior to or within 1 to 3 years after implementation of thinning, along with maintenance burning every 5-7 years in the ponderosa pine vegetation type. This would maintain post treatment fuels conditions within those areas. Within the mixed conifer vegetation type, maintenance burning may not occur during the life of the project due to its historical fire return interval. Because of this, wildfire flame lengths and down woody debris would increase over the 20 year period for Alternatives two and three (Table 16,Table 17, Table 26 and Table 27).

By treating the Flagstaff Watershed Protection area, we reduce the risk of a crown fire starting in the project areas and spreading as a crown fire through adjacent areas. This treatment would further reduce the risk of crown fire spreading to nearby urban interface areas at risk and improve this fire adapted ecosystem.

Alternatives 2 and 3 would include a permanent campfire closure order for the DLH portion, and also would decommission approximately 4 miles of Forest Roads. This would result in a decrease in campfires and unauthorized public access, thereby reducing the threat of human-caused fires within the DLH.

Alternatives 2 and 3 address the purpose and need more so than Alternative 4 by reducing the crown bulk density (thinning), reducing the canopy closure (thinning), increasing the effective crown base height in most sites (thinning and prescribed burning over time), and reducing the number of potential firebrands and shortening the distance at which spot fires would be expected to occur (thinning and prescribed burning). Furthermore, Alternatives 2 and 3 meet the project goals and objectives because forest health would be improved from existing condition. The fire hazard would be drastically reduced in the project area from extreme, very high, and high, to mostly high, moderate, and low, and overall goals for community protection and resource protection would be met compared to the results of the No Action Alternative.

Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources

As described above, with no treatment, there would be more large, high severity fires than occurred historically, or than are sustainable within the project area. In recent years, fires on the Mogollon Rim that have taken human lives, destroyed homes/property/infrastructure, and produced high severity effects across large areas not adapted to high severity fire include Rodeo/Chediski 2002 (469,000 acres), Wallow 2011 (538,000 acres), and Whitewater 2012 (still burning at >290,000 acres as of June 20, 2012). Such fires permanently change tens of thousands of acres of forests when they burn with high severity in areas which are not adapted to high severity fire. There is broad consensus that such fires would burn in this area if there is no action taken, though the specific extent and location of the negative effects would not be known until an incident occurs. First order effects would include (but are not limited to): chemical and physical changes to soil, high levels of mortality across the burned area (assuming ~30 percent high severity), consumption and/or killing of the seed bank, consumption of organic material in soil, including flora and fauna, conversion of forested habitat to non-forested habitat. Second order fire effects would include (but are not limited to) erosion, flooding, debris flows, destroyed infrastructure, changes in visitation to the forest and the economies of local businesses that depend on visitors and degradation of water resources for wildlife and humans. Some of these effects would last just a few days or weeks (infrastructure would be rebuilt), some would take years to recover, some changes would be permanent. For example, topsoil is critical to healthy surface vegetation and would take centuries to recover though, with climate change, it is unknown exactly what the ecological trajectory would be. The loss of old growth and old trees would require decades and centuries to recover.

Alternative 2 – Propose Action with Cable Logging Emphasis on Steep Slopes

The DLH area includes approximately 7,569 acres; 836 acres are currently being treated under the Jack Smith Schultz project and roughly 769 acres are either non-treatable due to rock faces and/or boulder fields. Under Alternative 2, treatments in the DLH would include mechanical and hand thinning as well as prescribed fire on the remaining acres (approximately 5,963 acres), with the use of cable logging to remove cut material from steep, inaccessible slopes on approximately 1,185 acres

The MM area includes approximately 2,974 acres. Treatments would include mechanical and hand thinning as well as prescribed fire with approximately 106 acres of cable logging proposed.

Alternative 2 also proposes prescribed burning in the wet mixed conifer in the MM area. Burning techniques in the wet mixed conifer would target accumulated dead and down material rather than usual broadcast burning ignition patterns.

Direct and Indirect Effects

As discussed under Direct and Indirect Effects Common to Alternatives 2 and 3, the majority of effects between these two action alternatives would be the same. Therefore, only the differences are discussed here and under Alternative 3.

Prescribed fire would include initial pile burning to remove slash accumulated through harvesting, followed by broadcast burning. Within the ponderosa pine vegetation type, maintenance burning may occur every five to seven years following implementation in order to maintain lower fuel loading levels and to restore a frequent, low-severity fire regime. Mixed conifer stands may only receive one broadcast burn through the life of the project due to the historic Fire Return Interval. Effects of target burring accumulated dead and down fuels in wet mixed conifer would result in a decrease of available fuel loading that would otherwise be left and could potentially increase the likelihood of crown fire initiation. Other slash removal options as described in the Implementation Methods section could also be used in lieu of burning, including biomass removal.

Table 14 and Table 15 represent prescribed fire implementation effects by treatment types.

Table 14: Prescribed Fire Implementation Effects Dry Lake Hills ALternative 2

Alt.2 Prescribed Fire Implementation Effects by Treatment	Flame Length (ft.)	Scorch Height (ft.)	Smoke Emission (PM2.5)	Mortality (BA Killed)	Post Burn DWD 12+ (tons/acre)
Electronic Site – Structure Protection	**Not Modeled				
Grassland Restoration	**Not Modeled				
Ponderosa Pine Fuels Reduction - Hand Thin	**Not Modeled				
Aspen Treatment - Hand Thin	**Not Modeled				
Mixed Conifer - Hand Thin	3.8	22.8	0.14	10.4	7.8
MSO PAC - Hand Thin	3.7	22.1	0.1	4	14.9
Burn Only	4.9	30.6	0.08	19.4	2.7

Nest Core Burn Only	4.2	25.9	0.04	7.4	0.4*
Goshawk PFA MC Fuels Reduction GB	4	24.1	0.07	4.5	2.9
MSO PAC Fuels Reduction GB	2.6	12.5	0.09	4.4	7.8
MSO PAC Fuels Reduction Cable	2.6	12.6	0.1	3.8	8.8
Goshawk PFA PP Fuels Reduction GB	3.3	16.3	0.06	3.1	0.3*
Goshawk PFA Fuels Reduction Cable	3.2	15.9	0.09	4.6	1.1
Goshawk Nest Fuels Reduction	2.6	11.1	0.07	3.6	1.1
Schultz Nest - Hand Thin	3.6	21.1	0.1	15.8	15.8
Mixed Conifer Fuels Reduction GB	4.1	24.5	0.12	4.8	8
Mixed Conifer Fuels Reduction Cable	3.9	23.1	0.07	1.3	2.7
Ponderosa Pine Fuels Reduction GB	3.1	13.9	0.08	5	0.6*
Ponderosa Pine Fuels Reduction Cable	3.6	18.8	0.08	3.8	1.3
* Pretreatment values were less than 1 ton/acre for downed woody debris larger than 12", ** Stands not modeled due limited stand level data.					

Table 15: Prescribed Fire Implementation Effects Mormon Mountain Alternative 2.

Alt.2 Prescribed Fire Implementation Effects by Treatment	Flame Length (ft)	Scorch Height (ft)	Smoke Emission (PM2.5) (tons	Mortality (BA Killed)	Post Burn DWD 12+ (tons/acre)
Electronic Site - Structure Protection	**Not Modeled				
MSO Nest Mixed Conifer-Burn Only	1.8	7	0.18	9.1	7.1
MSO Nest Ponderosa Pine -Burn Only	2.2	10.2	0.09	11.6	0.3*
MSO Nest / Roost Recovery	3.7	21.5	0.11	11.7	1.0*
MSO PAC MC Fuels Reduction Cable	2.4	10.2	0.2	8.2	11.4
MSO PAC MC Fuels Reduction GB	2.1	8	0.16	7.6	7.8
MSO PAC PP Fuels Reduction Cable	2.9	13.9	0.9	4.9	0.8*
MSO PAC PP Fuels Reduction GB	2.9	14.2	0.1	3.8	0.8*
MSO PAC Fuels Reduction - Wet MC	4.5	24.8	0.24	33.9	14
Ponderosa Pine Fuels Reduction Pine/Oak	2.3	8.9	0.1	6.9	0.3*
* Pretreatment values were less than 1 ton/acre for downed woody debris larger than 12", ** not modeled due to no stand data.					

Table 16 and Table 17 represent post mechanical treatments and modeled wildfire conditions if a fire were to start and burn through the project areas under Schultz fire conditions.

Table 16: Dry Lake Hills average for proposed alternative 2 projected post-treatment conditions.

Alt. 2 Projected Conditions Dry Lake Hills Post-Treatment 2017 Post-Treatment 2033	Acreage	Canopy Base Height (ft.)	Dead and Downed Fuel (tons/acre) [avg]	Canopy Bulk Density (kg/M^3)	Canopy Closure (%)	Stems (Trees) per Acre	Post-treatment Wildfire Flame Length (ft.) (surface+crown fuels)	Potential Post-Treatment Wildfire Smoke Emission (PM2.5) (lbs/tons consumed)
Electronic Site – Structure Protection	6	**Not Modeled						
Grassland Restoration	60	**Not Modeled						
Ponderosa Pine Fuels Reduction - Hand Thin	150	**Not Modeled						
Aspen Treatment - Hand Thin	22	**Not Modeled						
Mixed Conifer - Hand Thin (2017)	132	23	15	0.05	50	112	7	0.17
Mixed Conifer - Hand Thin (2033)		23	19	0.06	55	107	7	0.17
MSO PAC - Hand Thin (2017)	202	22	20	0.04	55	82	6	0.12
MSO PAC - Hand Thin (2033)		23	23	0.04	56	75	6	0.13
Burn Only (2017)	270	19	10	0.5	53	140	15	0.13
Burn Only (2033)		**24**	17	0.55	57	129	16	0.14
Nest Core Burn Only (2017)	261	23	4	0.05	52	114	8	0.08
Nest Core Burn Only (2033)		**28**	10	0.05	53	102	8	0.10
MSO PAC Fuels Reduction GB (2017)	1167	23	13	0.04	54	307	7	0.11
MSO PAC Fuels Reduction GB (2033)		13	17	0.05	58	297	14	0.13
MSO PAC Fuels Reduction Cable (2017)		21	21	0.04	54	281	9	0.08
MSO PAC Fuels Reduction Cable (2033)		5	18	0.04	58	271	17	0.10
Goshawk PFA MC Fuels Reduction GB (2017)	100	24	7	0.04	50	200	7	0.09
Goshawk PFA MC Fuels Reduction GB (2033)		2	11	0.04	55	192	21	0.11
Goshawk PFA PP Fuels Reduction GB (2017)		29	4	0.02	49	106	4	0.05
Goshawk PFA PP Fuels Reduction GB (2033)		25	7	0.02	52	99	4	0.07
Goshawk PFA Fuels Reduction Cable (2017)		31	6	0.02	49	78	6	0.06
Goshawk PFA Fuels Reduction Cable (2033)		32	7	0.02	53	69	6	0.07

Goshawk Nest Fuels Reduction (2017)	100	23	5	0.03	54	177	5	0.05
Goshawk Nest Fuels Reduction (2033)		4	7	0.03	57	169	9	0.09
Schultz Nest - Hand Thin (2017)	122	11	22	0.07	52	210	10	0.17
Schultz Nest - Hand Thin (2033)		11	27	0.08	60	199	18	0.18
MSO Nest Roost Recovery – Hand Thin (2017)	72	21	14	0.06	54	97	7	0.17
MSO Nest Roost Recovery – Hand Thin (2033)		22	18	0.07	57	92	20	0.17
Mixed Conifer Fuels Reduction GB (2017)	1140	29	13	0.04	49	240	7	0.12
Mixed Conifer Fuels Reduction GB (2033)		9	16	0.04	53	232	15	0.14
Mixed Conifer Fuels Reduction Cable (2017)		21	21	0.04	49	308	9	0.13
Mixed Conifer Fuels Reduction Cable (2033)		5	18	0.05	53	297	19	0.14
Ponderosa Pine Fuels Reduction GB (2017)	1865	24	5	0.02	38	148	6	0.07
Ponderosa Pine Fuels Reduction GB (2033)		28	7	0.03	44	141	6	0.07
Ponderosa Pine Fuels Reduction Cable (2017)		27	6	0.02	40	93	7	0.07
Ponderosa Pine Fuels Reduction Cable (2033)		24	7	0.02	44	86	7	0.07
No Treatment	1605	-	-	-	-	-	-	-
** Not modeled due to limited stand data								

Table 17: Mormon Mountain average for proposed alternative 2 projected treatment conditions.

Alt. 2 Projected Conditions Mormon Mountain **Post-Treatment 2017** **Post-Treatment 2033**	**Acreage**	**Canopy Base Height (ft.)**	**Dead and Downed Fuel (tons/acre) [avg]**	**Canopy Bulk Density (kg/M^3)**	**Canopy Closure (%)**	**Stems (Trees) per Acre**	**Potential Flame Length (ft.)** ***Desired (4-8 ft.)***	**Potential Smoke Emission (PM2.5) (lbs/tons consumed)**
Electronic Site - Structure Protection	12	**Not Modeled						
MSO Nest Mixed Conifer-Burn Only	402	11	8	0.04	48	243	16	0.24
MSO Nest Mixed Conifer-Burn Only		12	24	0.05	53	227	19	0.27
MSO Nest Ponderosa Pine -Burn Only		11	8	0.04	48	243	16	0.16
MSO Nest Ponderosa Pine-Burn Only		12	24	0.05	53	227	19	0.18
MSO Nest / Roost Recovery (2017)	22	30	8.8	0.03	55	241	6	0.10
MSO Nest / Roost Recovery (2033)		30	15	0.04	61	235	6	0.14
MSO PAC MC Fuels Reduction Cable (2017)	1592	20	22	0.09	58	504	22	0.25
MSO PAC MC Fuels Reduction Cable (2033)		17	25	0.08	62	483	36	0.26
MSO PAC MC Fuels Reduction Ground Based (2017)		14	15	0.07	45	438	18	0.20
MSO PAC MC Fuels Reduction Ground Based (2033)		12	21	0.08	51	421	30	0.22
MSO PAC PP Fuels Reduction Cable (2017)		27	7	0.025	35	182	9	0.08
MSO PAC PP Fuels Reduction Cable (2033)		25	12	0.03	41	175	9	0.09
MSO PAC PP Fuels Reduction Ground Based(2017)		32	7	0.02	43	196	8	0.09
MSO PAC PP Fuels Reduction Ground Based (2033)		31	12	0.02	48	189	7	0.11
MSO PAC Fuels Reduction - Wet MC (2017)	180	9	28	0.10	60	382	33	0.38
MSO PAC Fuels Reduction - Wet MC (2033)		9	37	0.11	60	368	46	0.39
Ponderosa Pine Fuels Reduction Pine/Oak (2017)	766	30	7	0.01	42	240	5	0.08
Ponderosa Pine Fuels Reduction Pine/Oak (2033)		28	10	0.02	49	230	5	0.09
** Not modeled due to limited stand data								

Crown Fire Potential

Crown fire potential for Dry Lake Hills modeled under Schultz conditions shows active crown fire on 658 acres, passive crown fire on 93 and 6,686 acres of surface fire (refer to Appendix 2 maps).

Crown fire potential for Mormon Mountain modeled under Schultz conditions shows active crown fire on 63 acres, passive crown fire on 329 and 2,577 acres of surface fire (refer to Appendix 2 maps).

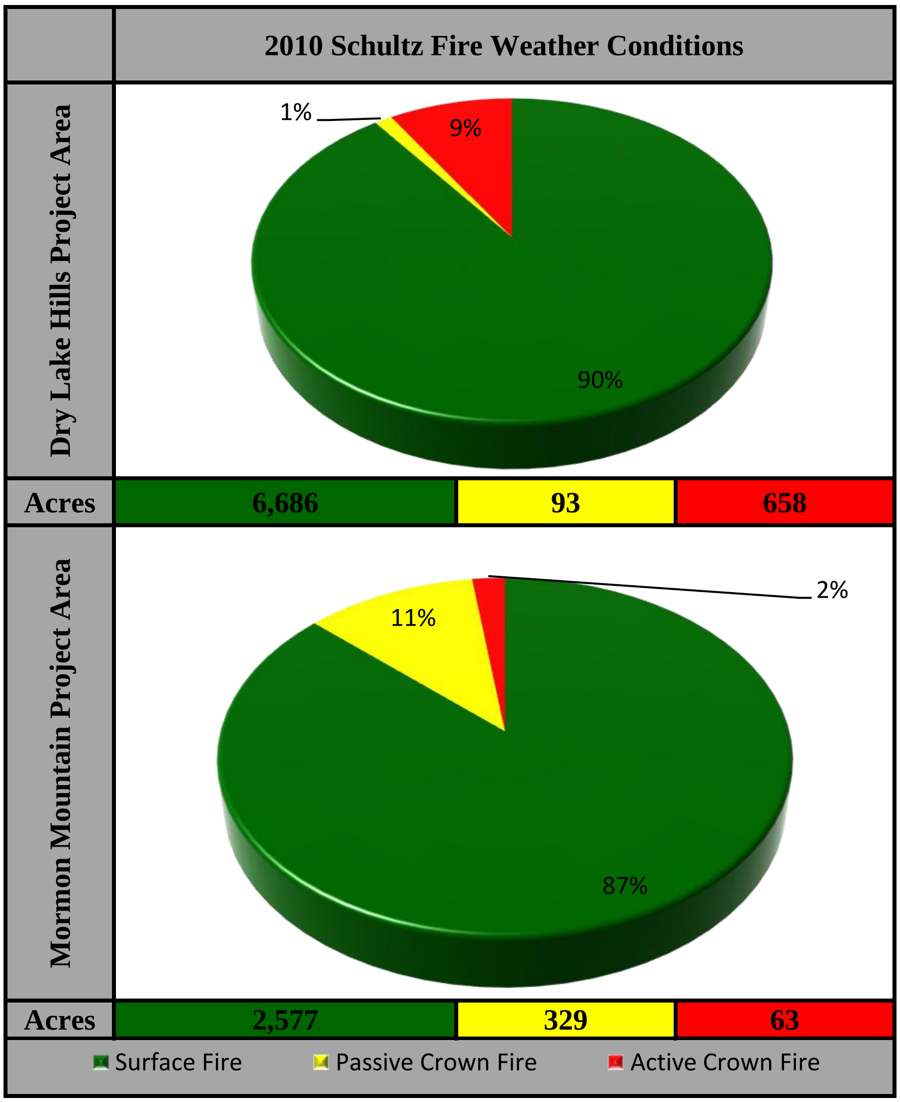


Figure 2 Modeled crown fire potential Alternative 2.

Table 18: Crown Fire potential Alt 2

Dry Lake Hills	Existing Crown Fire Potential (97^{th} %)	Existing Crown Fire Potential Schultz	Alternative 2, Schultz conditions
Active	5,480 acres	3,832 acres	658 acres
Passive	557 acres	749 acres	93 acres
Surface	1,426 acres	2,881acres	6,686 acres
Mormon Mountain	Existing Crown Fire Potential (97^{th} %)	Existing Crown Fire Potential Schultz	Alternative 2, Schultz conditions
Active	2,201 acres	2,068 acres	63acres
Passive	481 acres	725 acres	329 acres
Surface	286 acres	176 acres	2,577 acres
*Differences between 97^{th} percentile conditions and Schultz are negligible, therefore only post treatment conditions under Schultz are listed.			

Crown fire potential as modeled for Alternative 2 for the Dry Lake Hills unit under Schultz conditions shows a reduction of crown fire potential from 3,832 to 658 acres of active crown fire, 749 to 93 acres passive crown fire and 2,881 to 6,686 acres of surface fire behavior.

Crown fire potential as modeled for Alternative 2 for the Mormon Mountain unit under Schultz conditions shows a reduction of crown fire potential from 2,608 to 63 acres of active, 725 to 329 acres of passive crown fire and 176 to 2,577 acres of surface fire behavior

The objectives of the treatments proposed in alternative two and three are to move the treated areas towards desired future conditions which have reduced fuels. Proposed treatments restore and maintain ecosystem health in the project area and are in accordance with the Coconino Land Management Plan (1987, as amended).

Thinning and introducing prescribed fire in the project area would lower the risk of uncontrollable wildfire that would produce undesirable and perhaps detrimental effects to the ecosystem, especially in areas where fire hazard ratings are *extreme* to *high* and fire regime and condition classes are outside the natural range of variability.

Fire hazard ratings were calculated for existing and desired conditions for 50 percent (3,835 acres) of the Dry Lake Hills and 93 percent (2,784 acres) in the Mormon Mountain project areas, commensurate with the area in which field data was collected in each portion of the total project area.

The DLH fire hazard ratings after modeling implementation of Alternatives 2, 3 and 4 are illustrated in Table 19.

Table 19: Dry Lake Hills Fire Hazard post fire hazard Alts 2, 3&4

Existing Fire Hazard	Acres	Percent	**Post Treatment Fire Hazard**	Acres	Percent
Extreme	2,582	67%	Extreme	91	2%
Very High	72	4%	Very High	268	8%
High	613	15%	High	510	13%
Moderate	470	12%	Moderate	1,930	50%
Low	100	2%	Low	1,036	27%

Mormon Mountain Fire hazard ratings after modeling implementation of Alternatives 2, 3 and 4 is illustrated in Table 20.

Table 20 Mormon Mountain Fire hazard post treatment Alts 2 & 3

Existing Fire Hazard	Acres	Percent	**Post Treatment Fire Hazard**	Acres	Percent
Extreme	2089	75%	Extreme	526	18%
Very High	197	8%	Very High	10	1%
High	273	10%	High	273	9%
Moderate	173	6%	Moderate	736	26%
Low	51	1%	Low	1,284	46%

Modeling fire hazard after treatments within the project areas shows decreases in fire hazard, as Table 19 and Table 20 illustrate. However *extreme* and *very high* ratings are still present in both scenarios. This is because the stands are mixed conifer cover types and modeling did not show a drastic decrease in surface fuel loading. These stands have dead and down fuel loading of over 45 tons per acre and are on slopes greater than 30 percent.

Alternative 2 proposes to thin and prescribe burn 570 acres in the DLH area that are currently rated as *moderate* or *low* fire hazard. Within the MM area there are also 173 acres that are currently rated as *moderate* and 51 acres rated as *low*. Although these acres already have an acceptable fire hazard rating, proposed treatments would further improve stand composition, conditions, and structure that can lead to extreme fire behavior. Without the proposed thinning and burning, both current and future stand conditions would most likely promote extreme fire behavior within the urban interface if a fire occurred within and surrounding areas of the project area.

The following table is a comparison of the arrival times for post treatment conditions.

Table 21: Comparison Arrival time in acres/hour Alternative 2 & 3

Arrival Time	Intersection of FR 420 and 557 (the Y)		Intersection of 557rd and Oldham Trail		Paradise		Mormon Mountain 648 Rd	
	Existing Conditions	Post-Treatment Conditions	Existing Conditions	Post-Treatment Conditions	Existing Conditions	Post-Treatment Conditions	Existing Conditions	Post-Treatment Conditions
1st HR	51	1	469	23	259	91	197	1
2nd HR	318	12	1411	45	1217	324	607	4
3rd HR	960	25	2414	244	2012	584	1103	8
4th HR	1604	70	3482	484	2773	971	1614	22
5th HR	2803	192	4156	704	3438	1398	2508	81

Arrival time and ignition locations are identified in Appendix 2.

The fire regime for the majority of the project would remain the same (fire regime 1) an open forest maintained by frequent low severity fires. The remaining portions of the project area are fire regime II characterized by a fire frequency between 0 and 35 years, but with a high severity (more than 75 percent of the dominant overstory replaced) and fire regime III a mosaic of open forest to mid-seral maintained by mixed severity fires recurring generally 35 to 100 years. Over the course of the 20 years analyzed, the vegetation condition classes would be greatly improved, where vegetation composition, structure, and fuels are similar to those of the natural regime and do not predispose the system to risk of loss of key ecosystem components. A wildfire occurring under post-treatment conditions would be characteristic of the historic fire regime behavior, severity, and patterns.

Table 22: Design Features and Mitigation Measures

Fire/Fuels	Slash Mats	In areas where slash mats are used to protect soils during harvesting activities, District fire/fuels personnel would determine if material should be piled and burned post-implementation where slash exceeds 4 inches in depth.
	Fuelwood Gathering	Areas of project-generated slash suitable for fuelwood gathering would be identified for public use. Those areas would be identified on the Forest website and on the map accompanying each fuelwood gathering permit.
	Slash Treatment	• Limit machine piling of slash within 300 feet of private property boundaries. • Limit hand piling within 50 feet of private property boundaries. • If a market for biomass exists during the time of implementation, biomass removal methods may be utilized in place of pile burning in areas identified for potential ground based harvesting, particularly in areas adjacent to residential property.

Cumulative Effects

The area analyzed for the cumulative fire effects of this project is the Flagstaff Ranger District, as this encompasses most of the forested land subject to the prevailing winds driving a wildfire into the community of Flagstaff and the surrounding areas. The project areas (DLH and MM) are within the Flagstaff Community Wildfire Protection Plan area (CWPP) the treatments proposed are in line with the goals and objectives set forth by the CWPP.

The time period analyzed for the cumulative fire effects of this project includes a twenty year period from 2013 to 2033. Prior to that time the only activities in the area that affected the fire hazard were aggressive fire suppression and the continuing growth of forest vegetation.

The effects of the Flagstaff Watershed Protection Project would cumulatively combine with other previously-analyzed forest health and fuel reduction projects that lie in the path of the prevailing winds around Flagstaff and its suburbs (Wing Mtn., Hart Prairie, Eastside, Ft. Valley Restoration, A-1 Multi-Product, Mars Hill, Ritter, Sinks, Mormon Lake Basin, Woody Ridge, Kachina Village, Lake Mary Fuel Reduction, Mountainaire, Elk Park, Jack Smith Schultz, Eastside, Marshall and Skunk Fuel Reduction) to reduce the risk of high severity fire impacting the City of Flagstaff. The treatments within these projects do not eliminate the chance of a crown fire, but greatly reduce the chance of a crown fire initiating within their bounds and spreading to adjacent lands.

The Flagstaff District is currently conducting analysis for the Turkey Butte - Barney Pasture Forest Health and Fuels Reduction Project, located approximately thirty miles south of the

Flagstaff area. However, this project would not have a cumulative effect on the fire behavior or fire hazard of the FWPP area due to the distance between the two project areas.

By treating the Flagstaff Watershed Protection area, the risk of a crown fire starting in the project areas and spreading as a crown fire through adjacent areas would be reduced. This treatment would further reduce the risk of crown fire spreading to nearby urban interface areas at risk and improve this fire adapted ecosystem.

The Four Forests Restoration Initiative (4FRI) is working on the Final Environmental Impact statement for treating around 600,000 acres, including most of the acres adjacent to Mormon Mountain, and many areas adjacent to Dry Lake Hills. The implementation of the 4FRI acres covered in the FEIS is expected to begin in late 2014 or 2015. The 4FRI will have significant impact on hazardous fuel loading and fire hazard on the Flagstaff District. The cumulative effects, when combined with FWPP, should provide effective protection of both Dry Lake Hills and Mormon Mountain from undesirable fire behavior and effects as treatments are implemented over the next ten years. Both the Dry lake hills portion and the Mormon Mountain areas overlap with 4FRI treatments, and implementation should occur simultaneously.

The effects of past treatments and wildfires within the area considered for cumulative effects could affect if and how wildfires burn into the treatment area. Vegetation/fuels in treated/burned areas are more likely to produce surface fires, which are easier to manage and are likely to produce effects that are beneficial to the ecosystems. Since existing conditions and proposed treatments vary widely across the projects discussed, and even within individual projects, it is difficult to summarize the fire effects. It is accurate to state that fire-induced tree mortality across all size classes would be dramatically reduced by these treatments.

According to Millar et al., resilient forests are “those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance (2007). Prescribed burning has been identified as an important management strategy for maintaining desired habitats in a changing climate with more natural disturbances (USDA FS 2010). The cumulative effects of FWPP and other similar fuels reduction/forest health restoration projects on the Flagstaff Ranger District would be to increase the resiliency of the forest to the effects of climate change.

It is also accurate to state that wildfires occurring in these treated areas would be easier to control and burn less severely with less acreage burned than if the areas were left untreated. These projects combine to form a defensible space for Flagstaff and its surrounding communities.

Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources

There would be impacts to air quality associated with the implementation of the proposed prescribed fire treatments; however National Ambient Air Quality Standards (NAAQS) would not be exceeded. Before any prescribed fires can be implemented, a prescribed burn plan must be written and signed by the authorizing line officer. For prescribed fire, burn plans include burn techniques, prescriptions, Emission Reduction Techniques, etc. that would be expected to maintain emissions levels at acceptable levels. Approval to burn on a given day must be approved by the Arizona Department of Environmental Quality (ADEQ) before a burn can be initiated. None of the proposed actions under this alternative are expected to exceed NAAQs, though nuisance smoke may increase to the degree that the public would tolerate as discussed in the Air Quality section of in this report.

Alternative 3 – Proposed Action without Cable Logging

Alternative 3 has the same treatment objectives as Alternative 2, but with different harvesting methods proposed to address visual, wildlife and soil concerns. Under Alternative 3, the same treatment types are proposed, but no cable logging would occur. Instead, in steep, inaccessible areas, helicopters and specialized steep-slope machinery would be utilized to remove material.

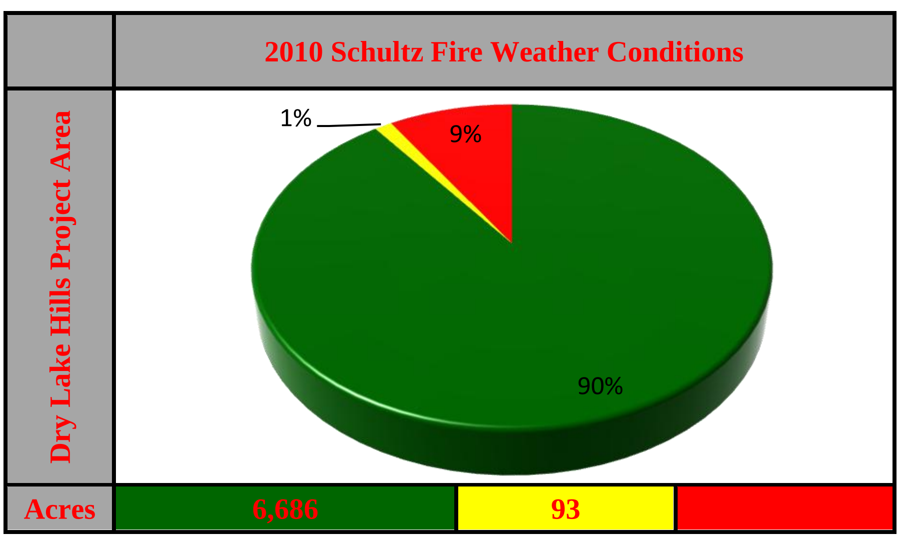
Direct and Indirect Effects

In general, effects to fuel and fire resources under Alternative 3 would be the same as those described in Alternative 2, with minor differences in acreages due to harvesting methods (see Direct and Indirect Effects Common to Alternatives 2 and 3). These minor differences affect modeling outputs related to crown fire potential so that the anticipated results differ slightly between the two alternatives, as shown in the tables and discussion below. It's important to note, however, that these differences are based on model limitations and spatial resolution, and implementation of Alternative 2 and 3 should have similar outcomes regarding the reduction of crown fire potential. Differences in prescribed fire outcomes are also evident as slight increases in flame length, mortality, scorch height and downed woody debris, primarily in the mixed conifer vegetation type on steep slopes.

Crownfire Potential

Crown fire potential for Dry Lake Hills modeled under Schultz conditions shows active crown fire on 658 acres, passive crown fire on 93 and 6,686 acres of surface fire (refer to Appendix 2 maps).

Crown fire potential for Mormon Mountain modeled under Schultz conditions shows active crown fire on 63 acres, passive crown fire on 329 acres and 2,577 acres of surface fire (refer to Appendix 2 maps). Due to consistency in treatments between Alts 2 & 3 for Mormon Mountain, Alts 2 and 3 were modeling using the same post-treatment condition data set. Under Alternative 3, there may be a slight increase in passive/active crown fire related to an increase in residual dead and downed fuel; however, this increase in negligible in the scope of modeling.



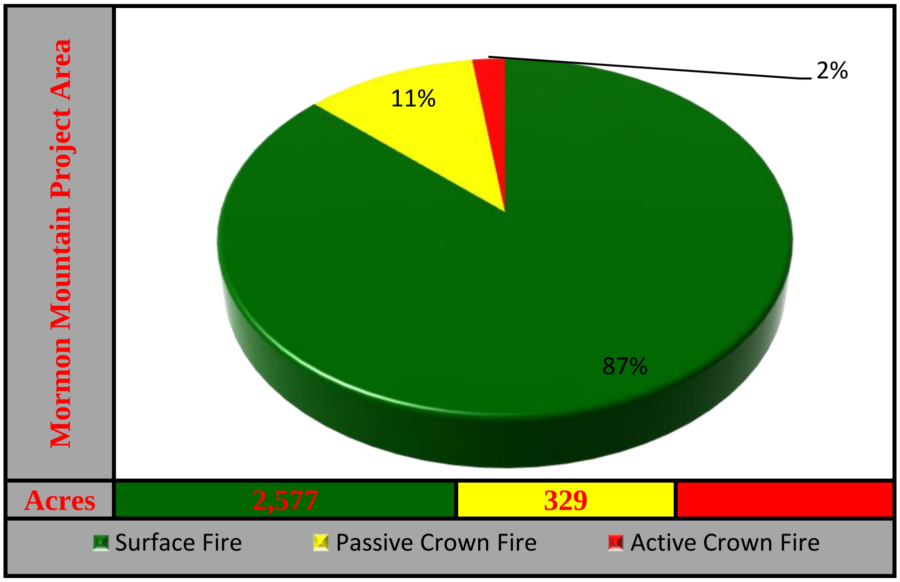


Figure 3 Modeled Crown Fire potential Alternative 3

Table 23: displays existing crown fire potential and modeled results of Alt 3

Dry Lake Hills	Existing Crown Fire Potential (97^{th} %)	Existing Crown Fire Potential Schultz	Alternative 2, Schultz conditions
Active	5,480 acres	3,832 acres	658 acres
Passive	557 acres	749 acres	93 acres
Surface	1,426 acres	2,881acres	6,686 acres
Mormon Mountain	Existing Crown Fire Potential (97^{th} %)	Existing Crown Fire Potential Schultz	Alternative 2, Schultz conditions
Active	2,201 acres	2,068 acres	63acres
Passive	481 acres	725 acres	329 acres
Surface	286 acres	176 acres	2,577 acres
*Differences between 97^{th} percentile conditions and Schultz are negligible, therefore only post treatment conditions under Schultz are listed.			

Crown fire potential as modeled for Alternative 2 for the Dry Lake Hills unit under Schultz conditions shows a reduction of crown fire potential from 3,832 to 658 acres of active crown fire, 749 to 93 acres passive crown fire and 2,881 to 6,686 acres of surface fire behavior.

Crown fire potential as modeled for Alternative 2 for the Mormon Mountain unit under Schultz conditions shows a reduction of crown fire potential from 2,608 to 63 acres of active, 725 to 329 acres of passive crown fire and 176 to 2,577 acres of surface fire behavior.

Prescribed Fire Effects

Slight differences in prescribed fire effects (flame length, scorch height, mortality and downed woody debris) are also evident between Alternative 2 and 3. Alternative 3 would leave more material on the ground compared to Alternative 2 because of harvesting methods.

Table 24: Prescribed Fire Implementation Effects Dry Lake Hills Alternative 3

Alt.3 Prescribed Fire Implementation Effects by Treatment	Flame Length (ft)	Scorch Height (ft)	Smoke Emission (PM2.5) (tons	Mortality (BA Killed)	Post Burn DWD 12+ (tons/acre)
Electronic Site – Structure Protection	**Not Modeled				
Grassland Restoration	**Not Modeled				
Ponderosa Pine Fuels Reduction - Hand Thin	**Not Modeled				
Aspen Treatment - Hand Thin	**Not Modeled				
Mixed Conifer - Hand Thin	3.8	22.8	0.14	10.4	7.8
MSO PAC - Hand Thin	3.7	22.1	0.1	4	14.9
Burn Only	4.9	30.6	0.08	19.4	2.7
Nest Core Burn Only	4.2	25.9	0.04	7.4	0.4*
Goshawk PFA MC Fuels Reduction GB	4	24.1	0.07	4.5	2.9
MSO PAC Fuels Reduction GB	2.6	12.5	0.09	4.4	7.8
MSO PAC Fuels Reduction Heli	2.6	12.5	0.1	3.2	10.8
MSO PAC Fuels Reduction SS	2.6	12.6	0.09	3.7	6.8
Goshawk PFA PP Fuels Reduction GB	3.3	16.3	0.06	3.1	0.3*
Goshawk PFA PP Fuels Reduction Heli	3.2	15.8	0.08	4.7	1.1
Goshawk Nest Fuels Reduction 70BA	2.6	11.1	0.07	3.6	1.1
Schultz Nest - Hand Thin	3.6	21.1	0.1	15.8	15.8
Mixed Conifer Fuels Reduction GB	4.1	24.5	0.12	4.8	8
Mixed Conifer Fuels Reduction Heli	4.2	25.6	0.12	4.6	8.8
Mixed Conifer Fuels Reduction SS	4.3	26.1	0.11	4.7	5.8
Ponderosa Pine Fuels Reduction GB	3.1	13.9	0.08	5	0.6*
Ponderosa Pine Fuels Reduction Heli	3.6	18.3	0.08	3.8	1.3
* Pretreatment values were less than 1 ton/acre for downed woody debris larger than 12", ** Not modeled due to limited stand data					

Table 25: Prescribed Fire Implementation Effects Mormon Mountain Alternative 3

Alt.3 Prescribed Fire Implementation Effects by Treatment	Flame Length (ft)	Scorch Height (ft)	Smoke Emission (PM2.5) (tons	Mortality (BA Killed)	Post Burn DWD 12+ (tons/acre)
Electronic Site - Structure Protection	**Not Modeled				
MSO Nest Mixed Conifer-Burn Only	1.8	7	0.18	9.1	7.1
MSO Nest Ponderosa Pine -Burn Only	2.2	10.2	0.09	11.6	0.3*
MSO Nest / Roost Recovery	3.7	21.5	0.11	11.7	1.0*
MSO PAC MC Fuels Reduction GB	2.1	8	0.16	7.6	7.8
MSO PAC PP Fuels Reduction GB	2.9	14.2	0.1	3.8	0.8*
MSO PAC Fuels Reduction - Wet MC	4.5	24.8	0.24	33.9	14
Ponderosa Pine Fuels Reduction Pine/Oak	2.3	8.9	0.1	6.9	0.3*
* Pretreatment values were less than 1 ton/acre for downed woody debris larger than 12", ** Not modeled due to limited stand data					

Table 26 and Table 27 represent post mechanical treatments and modeled wildfire conditions if a fire were to start and burn through the project areas under Schultz fire conditions.

Table 26: Dry Lake Hills average for proposed alternative 3 projected treatment conditions.

Alt. 3 Projected Conditions Dry Lake Hills *(Desired Conditions)* Post-Treatment 2017 / Post-Treatment 2033	Acreage	Canopy Base Height (ft.)	Dead and Downed Fuel (tons/acre) [avg]	Canopy Bulk Density (kg/M^3)	Canopy Closure (%)	Stems (Trees) per Acre	Potential Flame Length (ft.) *Desired (4-8 ft.)*	Potential Smoke Emission (PM2.5) (lbs/tons consumed)
Electronic Site – Structure Protection	6	**Not Modeled						
Grassland Restoration	60	**Not Modeled						
Ponderosa Pine Fuels Reduction - Hand Thin	150	**Not Modeled						
Aspen Treatment - Hand Thin (2017)	22	**Not Modeled						
Mixed Conifer - Hand Thin (2017)	85	23	15	0.05	50	112	7	0.17
Mixed Conifer - Hand Thin (2033)		23	19	0.06	55	107	7	0.17
MSO PAC - Hand Thin (2017)	202	22	20	0.04	55	82	6	0.12
MSO PAC - Hand Thin (2033)		23	23	0.04	56	75	6	0.14
Burn Only (2017)	270	19	10	0.5	53	140	15	0.13
Burn Only (2033)		24	17	0.55	57	129	16	0.15
Nest Core Burn Only (2017)	261	23	4	0.05	52	114	8	0.08
Nest Core Burn Only (2033)		28	10	0.05	53	102	8	0.10
MSO PAC Fuels Reduction GB (2017)	1195	23	13	0.04	54	307	7	0.11
MSO PAC Fuels Reduction GB (2033)		13	17	0.05	58	297	14	0.13
MSO PAC Fuels Reduction Heli (2017)		19	16	0.04	55	269	5	0.12
MSO PAC Fuels Reduction Heli (2033)		5	17	0.04	58	260	12	0.14
MSO PAC Fuels Reduction SS (2017)		25	13	0.04	56	185	5	0.10
MSO PAC Fuels Reduction SS (2033)		12	17	0.04	60	375	10	0.13
Goshawk PFA PP Fuels Reduction GB (2017)	359	29	4	0.02	49	106	4	0.05
Goshawk PFA PP Fuels Reduction GB (2033)		25	7	0.02	52	99	4	0.07
Goshawk PFA PP Fuels Reduction Heli (2017)		30	6	0.02	45	79	6	0.07
Goshawk PFA PP Fuels Reduction Heli (2033)		31	7	0.02	50	70	6	0.07

Goshawk PFA MC Fuels Reduction GB (2017)		24	7	0.04	50	200	7	0.14
Goshawk PFA MC Fuels Reduction GB (2033)		2	11	0.04	55	192	21	0.11
Goshawk Nest Fuels Reduction 70BA (2017)	100	23	5	0.03	50	177	5	0.05
Goshawk Nest Fuels Reduction 70BA (2033)		4	7	0.03	55	169	9	0.09
Schultz Nest - Hand Thin (2017)	122	11	22	0.07	52	210	10	0.17
Schultz Nest - Hand Thin (2033)		11	27	0.08	60	199	18	0.18
MSO Nest Roost Recovery – Hand Thin (2017)	72	21	14	0.06	54	97	7	0.17
MSO Nest Roost Recovery – Hand Thin (2033)		22	18	0.07	57	92	20	0.17
Mixed Conifer Fuels Reduction GB (2017)	1158	29	13	0.4	49	240	7	0.12
Mixed Conifer Fuels Reduction GB (2033)		9	16	0.04	53	232	15	0.14
Mixed Conifer Fuels Reduction Heli (2017)		21	21	0.04	41	308	9	0.13
Mixed Conifer Fuels Reduction Heli (2033)		5	18	0.05	45	297	19	0.13
Mixed Conifer Fuels Reduction SS (2017)		33	11	0.02	45	375	8	0.17
Mixed Conifer Fuels Reduction SS (2033)		1	14	0.03	50	365	16	0.13
Ponderosa Pine Fuels Reduction GB (2017)	1865	24	5	0.02	38	148	6	0.07
Ponderosa Pine Fuels Reduction GB (2033)		28	7	0.03	44	141	6	0.07
Ponderosa Pine Fuels Reduction Heli (2017)		26	6	0.02	40	86	7	0.06
Ponderosa Pine Fuels Reduction Heli (2033)		26	7	0.02	43	79	7	0.07
No Treatment	1605							
** Not modeled due to limited stand data								

Table 27: Mormon Mountain average for proposed alternative 3 projected treatment conditions.

Alt. 3 Projected Conditions Mormon Mountain (Desired Conditions) **Post-Treatment 2017** **Post-Treatment 2033**	**Acreage**	**Canopy Base Height (ft.)**	**Dead and Downed Fuel (tons/acre) [avg]**	**Canopy Bulk Density (kg/M^3)**	**Canopy Closure (%)**	**Stems (Trees) per Acre**	**Potential Flame Length (ft.) Desired (4-8 ft.)**	**Potential Smoke Emission (PM2.5) (lbs/tons consumed)**
Electronic Site - Structure Protection	12	**Post Treatment Conditions Not Modeled						
MSO Nest Mixed Conifer-Burn Only	402	11	8	0.04	48	243	16	0.24
MSO Nest Mixed Conifer-Burn Only		12	24	0.05	53	227	19	0.27
MSO Nest Ponderosa Pine -Burn Only		11	8	0.04	48	243	16	0.16
MSO Nest Ponderosa Pine-Burn Only		12	24	0.05	53	227	19	0.18
MSO Nest / Roost Recovery (2017)	22	30	8.8	0.03	55	241	6	0.10
MSO Nest / Roost Recovery (2033)		30	15	0.04	61	235	6	0.14
MSO PAC MC Fuels Reduction Ground Based (2017)	1592	14	15	0.07	58	438	18	0.20
MSO PAC MC Fuels Reduction Ground Based (2033)		12	21	0.08	62	421	30	0.22
MSO PAC PP Fuels Reduction Ground Based(2017)		32	7	0.02	35	196	8	0.09
MSO PAC PP Fuels Reduction Ground Based (2033)		31	12	0.02	41	189	7	0.11
MSO PAC Fuels Reduction - Wet MC (2017)	180	9	28	0.10	60	382	33	0.38
MSO PAC Fuels Reduction - Wet MC (2033)		9	37	0.11	60	368	46	0.39
Ponderosa Pine Fuels Reduction Pine/Oak (2017)	766	30	7	0.01	42	240	5	0.08
Ponderosa Pine Fuels Reduction Pine/Oak (2033)		28	10	0.02	49	230	5	0.09
** Not modeled due to limited stand data								

Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources

Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources would be identical to those discussed for Alternative 2.

Alternative 4 – Minimal Treatment Approach

This alternative would result in similar effects to those described in the Direct and Indirect Effects Common to Alternatives 2 and 3; however the purpose of Alternative 4 is to analyze the minimum amount of treatment necessary to meet the purpose and need. Therefore the effects would occur to a lesser degree (e.g. on fewer acres and with less intensity). Alternative 4 would treat 2,504 fewer acres in the DLH and 632 fewer acres on MM than under Alternatives 2 and 3.

Treatments are proposed for those areas with dense fuel loading where topography aligns with dominant winds and the probability of severe effects to soil resources from a wildfire is greater, based on FLAM MAP 5.0 modeling of both fire behavior and fire spread under Schultz fire weather conditions. Specifically, factors considered include: fire risk rating, potential damage to soils (from high severity fire and also harvesting methods), MSO habitat, and the type of harvesting methods necessary to affect change.

Under Alternative 4, 3,459 acres along the base of Dry Lake Hills and Mount Elden and the upper, flatter tops would receive basically the same treatments proposed in Alternatives 2 and 3, though under this alternative more areas are proposed for hand thinning and prescribed burning instead of cable or helicopter logging in order to reduce the potential impacts from temporary road network associated with those harvesting methods. Additionally, treatments are focused on the area south and east of FR420; the portion of the project area between FR420 and the Kachina Peaks Wilderness would still be treated but under the constraints of the analysis and decision for the Jack Smith Schultz Fuels Reduction and Forest Health Restoration Project. Thus, no new analysis would be performed for those areas under this alternative.

The Spruce Avenue Wash was identified as a high priority area due to the fuel loading, topography, size and also its location relative to the City of Flagstaff and MSO PACs. The portion of the Elden MSO PAC within the Spruce Avenue Wash would also be treated under the same parameters described in Alternatives 2 and 3.The Schultz MSO PAC and nest core were identified in conjunction with the FWS as high priority areas, and would also receive the same treatment described for Alternatives 2 and 3.

For Mormon Mountain, treatments would occur on 2,343 acres. The same methodology used for treatment placements in the Dry Lake Hills area was applied to Mormon Mountain to determine where to focus treatments. Under Alternative 4, the wet mixed conifer belt and MSO nest cores would not be treated; however treatments would occur below and above that belt.

Areas not included in this alternative would be designated as No Treatment. All treated acres would include prescribed burning in the manner described under Alternative 2 and 3: initially pile burning to remove slash accumulated through harvesting, followed by broadcast burning. Maintenance burning may occur every five to seven years following implementation in order to maintain lower fuel loading levels and to restore a frequent, low-severity fire regime. Mixed conifer may only receive one broadcast burn through the life of the project due to the historic Fire Return Interval in some vegetation types is historically longer than the life of this project. Other slash removal options as described in the Implementation Methods section could also be used in lieu of burning, including biomass removal.

Direct and Indirect Effects

Ground Fuels and Vegetation

Direct effects of Alternative 4 would be consistent with other similar fuels treatment projects on the Flagstaff Ranger District: prescribed fire would reduce surface fuels, raise crown base heights, reduce stems per acre and improve stand conditions. Prescribed fire may also result in an increase in mortality and reduce the amount of available logs and snags (Table 28 and Table 29), consistent with the other two action alternatives, but on fewer acres.

Table 28: Prescribed Fire Implementation Effects Dry Lake Hills Alternative 4.

Alt.4 Prescribed Fire Implementation Effects by Treatment	Flame Length (ft)	Scorch Height (ft)	Smoke Emission (PM2.5) (tons	Mortality (BA Killed)	Post Burn DWD 12+ (tons/acre)
Aspen Treatment - Hand Thin	**Not Modeled				
Electronic Site Structure Protection	**Not Modeled				
Goshawk Nest Fuels Reduction	2.6	11.1	0.07	3.6	1.1
Goshawk PFA MC Fuels Reduction GB	4	24.1	0.07	4.5	2.9
Goshawk PFA PP Fuels Reduction GB	3.2	15	0.07	3.4	0.4*
MSO Nest Fuels Reduction - Hand Thin	3.2	15.8	0.07	3.4	0.4*
MSO PAC MC Fuels Reduction GB	2.6	12.6	0.1	3.3	10.5
MSO PAC PP Fuels Reduction GB	2.7	13.3	0.6	3.9	0.4*
MSO PAC Fuels Reduction - Hand Thin	3.7	22.1	0.1	4	14.9
Mixed Conifer Fuels Reduction GB	4.1	24.5	0.12	4.8	8
Ponderosa Pine Fuels Reduction GB	3.1	14	0.08	5.6	0.2*
* Pretreatment values were less than 1 ton/acre for downed woody debris larger than 12", ** Not modeled due to limited stand data					

Table 29 Prescribed Fire Implementation Effects Mormon Mountain Alternative 4.

Alt.4 Prescribed Fire Implementation Effects by Treatment	Flame Length (ft)	Scorch Height (ft)	Smoke Emission (PM2.5) (tons	Mortality (BA Killed)	Post Burn DWD 12+ (tons/acre)
Electronic Site - Structure Protection	**Not Modeled				
MSO Nest Mixed Conifer-Burn Only	1.8	7	0.18	9.1	7.1
MSO Nest Ponderosa Pine -Burn Only	2.2	10.2	0.09	11.6	0.3*
MSO Nest / Roost Recovery	3.7	21.5	0.11	11.7	1.0*

MSO PAC MC Fuels Reduction GB	2.1	8	0.16	7.6	7.8
MSO PAC PP Fuels Reduction GB	2.9	14.2	0.1	3.8	0.8*
MSO PAC Fuels Reduction - Wet MC	4.5	24.8	0.24	33.9	14
Ponderosa Pine Fuels Reduction Pine/Oak	2.3	8.9	0.1	6.9	0.3*
* Pretreatment values were less than 1 ton/acre for downed woody debris larger than 12", ** Not modeled due to limited stand data					

Fire Suppression Efforts

Under Alternative 4, approximately 3,136 acres would not be treated in the project area, resulting in a lesser probability of containing a wildfire during an operational period if a fire were to start in the untreated areas. Fire suppression would likely have to focus containment efforts on the base of the slopes and ridge tops to be most effective.

Wildfire Hazard Potential

The direct and indirect effects are the same as Alternatives 2 and 3, with the exception that treatments are on a smaller scale and the project area at large could still have areas that are susceptible to high severity fires. Treatments in Alternative 4 would mitigate some potential for large scale fires; however since the entire area would not be treated, the project areas could be adversely affected by fires starting in neighboring stands and spreading through the Alternative four project boundary. Additionally a direct effect of a wildfire occurring outside of the Alternative 4 boundaries could have adverse impacts to neighborhoods and communities that lie in the immediate areas surrounding the two project areas.

Alternative 4 would also include the permanent campfire closure order for the DLH portion and approximately 4 miles of decommissioned Forest Roads, which would result in a decrease in campfires and unauthorized public access, thereby reducing the threat of human-caused fires within the DLH.

Alternative 4 would address the purpose and need by reducing the crown bulk density (thinning), reducing the canopy closure (thinning), increasing the effective crown base height in most sites (thinning and prescribed burning over time), and reducing the number of potential firebrands and shortening the distance at which spot fires would be expected to occur (thinning and prescribed burning), but to a lesser degree than Alternatives 2 and 3. Crown fire potential would be reduced under this alternative (see Table 30), but only on those acres treated. The 3,136 total acres left untreated would retain the same crown fire potential as the No Action Alternative.

Crown fire potential for Dry Lake Hills modeled under Schultz conditions shows active crown fire on 2,326 acres, passive crown fire on 336 and 4,757 acres of surface fire (refer to Appendix 2 maps).

Crown fire potential for Mormon Mountain modeled under Schultz conditions shows active crown fire on 558 acres, passive crown fire on 240 and 2,167 acres of surface fire (refer to Appendix 2 maps).

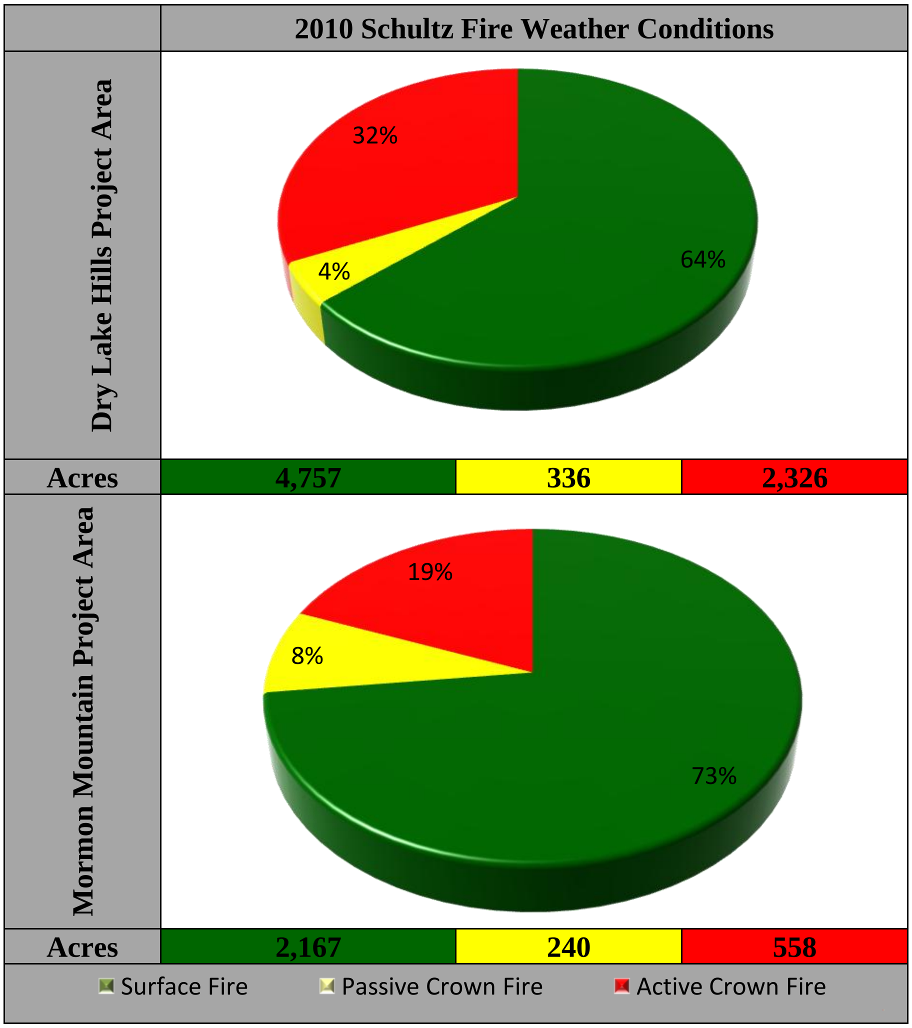


Figure 4 Modeled Crown Fire potential Alternative 4

Table 30: Existing Crown fire potential and modeled Alt. 4

Dry Lake Hills	Existing Crown Fire Potential (97^{th} %)	Existing Crown Fire Potential Schultz	Alternative 4, Schultz conditions
Active	5,480 acres	3,832 acres	2,326 acres
Passive	557 acres	749 acres	336 acres
Surface	1,426 acres	2,881acres	4,757 acres
Mormon Mountain	Existing Crown Fire Potential (97^{th} %)	Existing Crown Fire Potential Schultz	Alternative 4, Schultz conditions
Active	2,201 acres	2,068 acres	558 acres
Passive	481 acres	725 acres	240 acres
Surface	286 acres	176 acres	2,167 acres
*Differences between 97^{th} percentile conditions and Schultz are negligible, therefore only post treatment conditions under Schultz are listed.			

Implementation of Alternative 3 Dry Lake Hills modeled under Schultz conditions shows a reduction of crown fire potential from 3,832 to 2,326 acres of active crown fire, 749 to 336 acres of passive crown fire and 2,881to 4,757acres of surface fire behavior.

Within the Mormon Mountain project area modeled under Schultz conditions shows a reduction of crown fire potential from 2,068 to 558 acres of active, 725 to 240 acres passive crown fire and 176 to 2,167 acres of surface fire behavior.

Table 31 and Table 32 represent post mechanical treatments and modeled wildfire conditions if a fire were to start and burn through the project areas under Schultz fire conditions.

Table 31: Dry Lake Hills average for proposed alternative 4 projected treatment conditions

Alt. 4 Projected Conditions Dry Lake Hills (*Desired Conditions*) Post-Treatment 2017 Post-Treatment 2033	Acreage	Canopy Base Height (ft.)	Dead and Downed Fuel (tons/acre) [avg]	Canopy Bulk Density (kg/M^3)	Canopy Closure (%)	Stems (Trees) per Acre	Potential Flame Length (ft.) *Desired (4-8 ft.)*	Potential Smoke Emission (PM2.5) (lbs/tons consumed)
Aspen Treatment - Hand Thin (2017)	2	**Not Modeled						
Electronic Site Structure Protection	6	**Not Modeled						
Goshawk Nest Fuels Reduction (2017)	100	23	5	0.03	54	177	5	0.05
Goshawk Nest Fuels Reduction (2033)		4	7	0.03	57	169	9	0.09
Burn Only (2017)	67	19	10	0.5	53	140	15	0.13
Burn Only (2033)		24	17	0.55	57	129	16	0.15
Goshawk PFA MC Fuels Reduction GB (2017)	286	24	7	0.04	50	200	7	0.14
Goshawk PFA MC Fuels Reduction GB (2033)		2	11	0.04	55	192	21	0.11
Goshawk PFA PP Fuels Reduction GB (2017)		27	5	0.03	49	93	4	0.06
Goshawk PFA PP Fuels Reduction GB (2033)		21	8	0.03	52	87	4	0.08
MSO Nest Fuels Reduction - Hand Thin (2017)	122	11	22	0.07	54	210	10	0.17
MSO Nest Fuels Reduction - Hand Thin (2033)		11	27	0.08	57	199	18	0.18
MSO PAC MC Fuels Reduction GB (2017)	568	19	16	0.04	50	434	5	0.12
MSO PAC MC Fuels Reduction GB (2033)		4	19	0.04	55	422	15	0.15
MSO PAC PP Fuels Reduction GB (2017)		23	5	0.04	49	153	5	0.05
MSO PAC PP Fuels Reduction GB (2033)		18	9	0.04	52	144	8	0.09
MSO PAC Fuels Reduction - Hand Thin (2017)	228	22	20	0.04	54	82	6	0.12
MSO PAC Fuels Reduction - Hand Thin (2033)		23	23	0.04	60	75	6	0.14
Mixed Conifer Fuels Reduction GB (2017)	542	29	13	0.4	49	240	7	0.12
Mixed Conifer Fuels Reduction GB (2033)		9	16	0.04	53	232	15	0.14
Ponderosa Pine Fuels Reduction GB (2017)	1400	28	5	0.02	38	111	6	0.07
Ponderosa Pine Fuels Reduction GB (2033)		29	7	0.03	44	104	6	0.07
No Treatment	4110							

** Not modeled due to limited stand data

Table 32: Mormon Mountain average for proposed alternative 4 projected treatment conditions.

Alt. 4 Projected Conditions Mormon Mountain (Desired Conditions) / **Post-Treatment 2017** / **Post-Treatment 2033**	**Acreage**	**Canopy Base Height (ft.)**	**Dead and Downed Fuel (tons/acre) [avg]**	**Canopy Bulk Density (kg/M^3)**	**Canopy Closure (%)**	**Stems (Trees) per Acre**	**Potential Flame Length (ft.) Desired (4-8 ft.)**	**Potential Smoke Emission (PM2.5) (lbs/tons consumed)**
Electronic Site - Structure Protection	12	**Not Modeled						
MSO Nest Mixed Conifer-Burn Only	33	11	8	0.04	48	243	16	0.24
MSO Nest Mixed Conifer-Burn Only		12	24	0.05	53	227	19	0.27
MSO Nest Ponderosa Pine -Burn Only		11	8	0.04	48	243	16	0.16
MSO Nest Ponderosa Pine-Burn Only		12	24	0.05	53	227	19	0.18
MSO Nest / Roost Recovery (2017)	22	30	8.8	0.03	55	241	6	0.10
MSO Nest / Roost Recovery (2033)		30	15	0.04	61	235	6	0.14
MSO PAC MC Fuels Reduction Ground Based (2017)	1509	14	15	0.07	45	438	18	0.20
MSO PAC MC Fuels Reduction Ground Based (2033)		12	21	0.08	51	421	30	0.22
MSO PAC PP Fuels Reduction Ground Based(2017)		32	7	0.02	43	196	8	0.09
MSO PAC PP Fuels Reduction Ground Based (2033)		31	12	0.02	48	189	7	0.11
MSO PAC Fuels Reduction - Wet MC (2017)		14	15	0.07	60	437	18	0.38
MSO PAC Fuels Reduction - Wet MC (2033)		12	21	0.08	60	421	30	0.39
Ponderosa Pine Fuels Reduction Pine/Oak (2017)	766	30	7	0.01	42	240	5	0.08
Ponderosa Pine Fuels Reduction Pine/Oak (2033)		28	10	0.02	49	230	5	0.09
No Treatment	631							
** Not modeled due to limited stand data								

The following table is a comparison of the arrival times for post treatment conditions.

Table 33: Comparison Arrival time in acres/hour Alternative 4

Arrival Time	Intersection of FR 420 and 557 (the Y)		Intersection of 557rd and Oldham Trail		Paradise		Mormon Mountain 648 Rd	
	Existing Conditions	Post-Treatment Conditions	Existing Conditions	Post-Treatment Conditions	Existing Conditions	Post-Treatment Conditions	Existing Conditions	Post-Treatment Conditions
1st HR	51	1	469	14	259	26	197	6
2nd HR	318	3	1,411	20	1,217	148	607	185
3rd HR	960	9	2,414	32	2,012	395	1,103	343
4th HR	1,604	64	3,482	170	2,773	882	1,614	504
5th HR	2,803	206	4,156	424	3,438	1,296	2,508	734

Arrival Time acreages for Dry Lake Hills under Alternative 4 are slightly smaller than Alternative 2-3 modeling (Table 21) due to the fact that Alternative 4 does not alter fuel model composition as severely as Alternatives 2&3. Alternatives 2-3 have a higher component of Grass/Shrub fuel models that contribute to faster fire spread; whereas, the fire type be less severe than Alternative 4. Arrival time and ignition locations are identified in Appendix 2.

Cumulative Effects

Cumulative effects for alternative 4 are concurrent with Alternatives 2 and 3, except to a lesser degree.

Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources

Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources would be identical to those discussed under Alternative 2, but to a lesser degree as fewer acres would be treated under Alternative 4. .

Air Quality

Introduction

Air impacts are felt and measured by the concentration of emissions at a given location, be it a town, a house, or an air quality monitor. There are no reliable methods of predicting concentrations at specific locations years in advance of a prescribed fire. This analysis does not attempt or pretend to predict the actual total emissions that would be produced under each alternative. Rather it aims to present a rationale for which alternatives are likely to produce "less" or "more" emissions. It assumes that, over time, there is some degree of correlation between total emission production, and total air quality impacts. Impacts are measured and evaluated based on the concentration of emissions at a specific location, not the total amount of emissions. Though meteorological conditions vary immensely by time of day, time of year, and from one weather system to the next, over the course of years the averaging effect over time of these varying conditions supports a correlation between total emissions and total impacts (Kleindienst 2012). The Dry Lake Hills unit of the Flagstaff Watershed Protection Project area is in the Little Colorado River Airshed, and the Mormon Mountain unit is within the Verde River Airshed. Smoke emitted from a wildfire or a prescribed fire will settle in to drainages adjacent to the units.

Diurnal patterns of air movement cause smoke from the Dry Lake Hills area can settle within the greater Flagstaff area, with most of it draining towards the Rio De Flag. Smoke emitted from Mormon Mountain will settle in the Village of Mormon Lake and can drain west towards Munds Park and Munds Canyon, eventually draining to Oak Creek Canyon.

Flagstaff is located to the south of the Dry Lake Hills (DLH) unit with the housing and neighborhoods immediately adjacent to the project boundary. The Kachina Peaks Wilderness is located north of DLH, and will be treated as a Class I area as indicated in the Coconino Land Management Plan (1987, as amended).

The Arizona Department of Environmental Quality (ADEQ) models emissions/pollutants from all prescribed burning within the state. Any prescribed burn planned by the Forest Service must be approved by ADEQ on a daily basis. ADEQ will not allow more acres burned per day, per air shed, than is acceptable with current air quality forecasts.

When the US Forest Service conducts prescribed burning, the burn boss is responsible for monitoring smoke plume trajectories to assure impacts are within predicted values. The burn boss makes changes as needed when unpredicted weather threatens stronger impacts.

Existing Condition

There are several highly used FS roads within the project boundaries. Recreationists use these roads in conjunction with Highway 180 and Lake Mary Rd to access many areas on which to recreate within the project areas. Most visitors who take advantage of the recreation opportunities that exist within the project areas do so mostly during the spring, summer, and fall months. Some of these activities include hiking, recreational vehicle camping as well as tent camping, hunting, wildlife viewing, scenic driving, and ATV/UTV use. People also cross country ski, snowmobile, and sled in the selected areas during the winter months (see also the Recreation Specialist Report).

The prevailing winds for the FWPP area are out of the southwest. However, as fronts pass, winds can arrive from any direction for a period ranging from a few hours to three days. Atmospheric inversions can prevent smoke from dispersing. Within the project area, inversions mostly occur between October and December. Stagnant atmospheric conditions result from low mixing heights and light transport winds. These conditions, when they occur, may last from twelve hours to several days (Arizona Department of Environmental Quality, Fort Collins Weather Database).

Environmental Consequences

Alternative 1- No Action

Direct and Indirect Effects

Alternative 1 would produce no direct effects since no prescribed burning would occur. However, analyzing the emissions from a high severity wildfire occurring within the project area that has not been treated using the Forest Vegetation Simulator (FVS) and Fire and Fuels Extension (FFE), the amount of fuel consumed and the smoke generated by a high intensity wildfire would be greater than that under alternatives 2, 3, or 4.

Under extreme weather conditions, a wildfire would mostly likely burn more acres than would generally be burned with a prescribed burn in a day) because of the difficulty of suppressing a wildfire in an untreated area. The resulting smoke from such a wildfire would spread wider and farther than with prescribed fire. Nighttime smoke would reach farther and impact the nearby communities more severely. Smoke would exceed air quality standards in both density and duration.

Figure 4: Predicted reduction in potential wildfire emission of PM 2.5 per alternative Dry Lake Hills

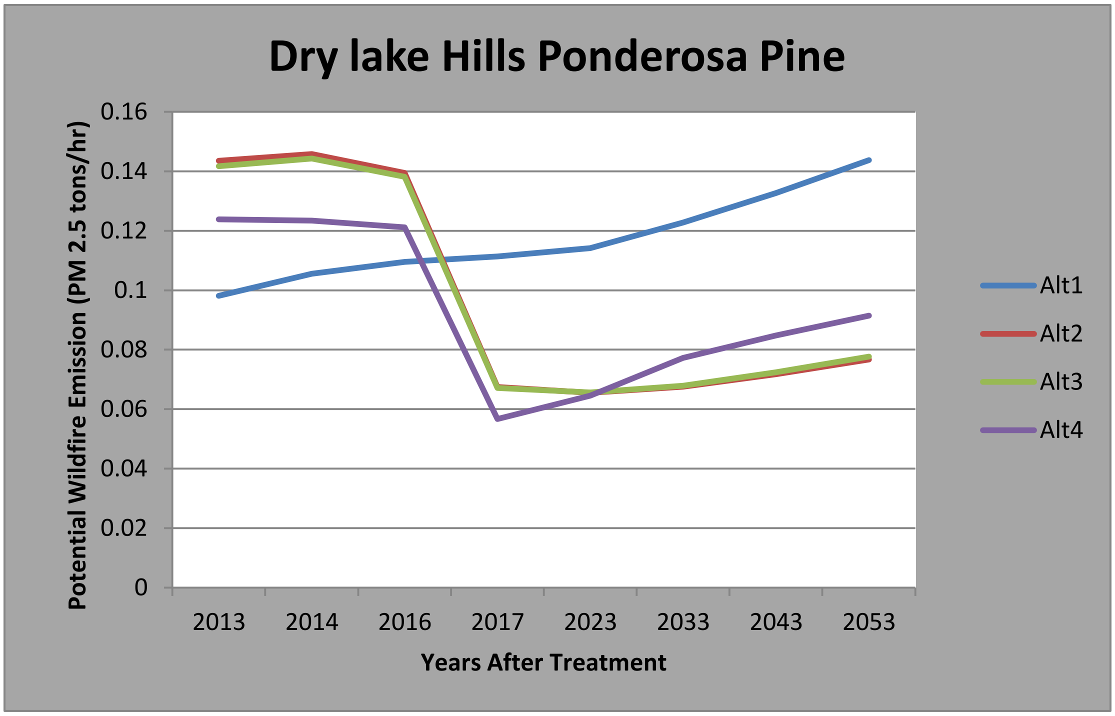
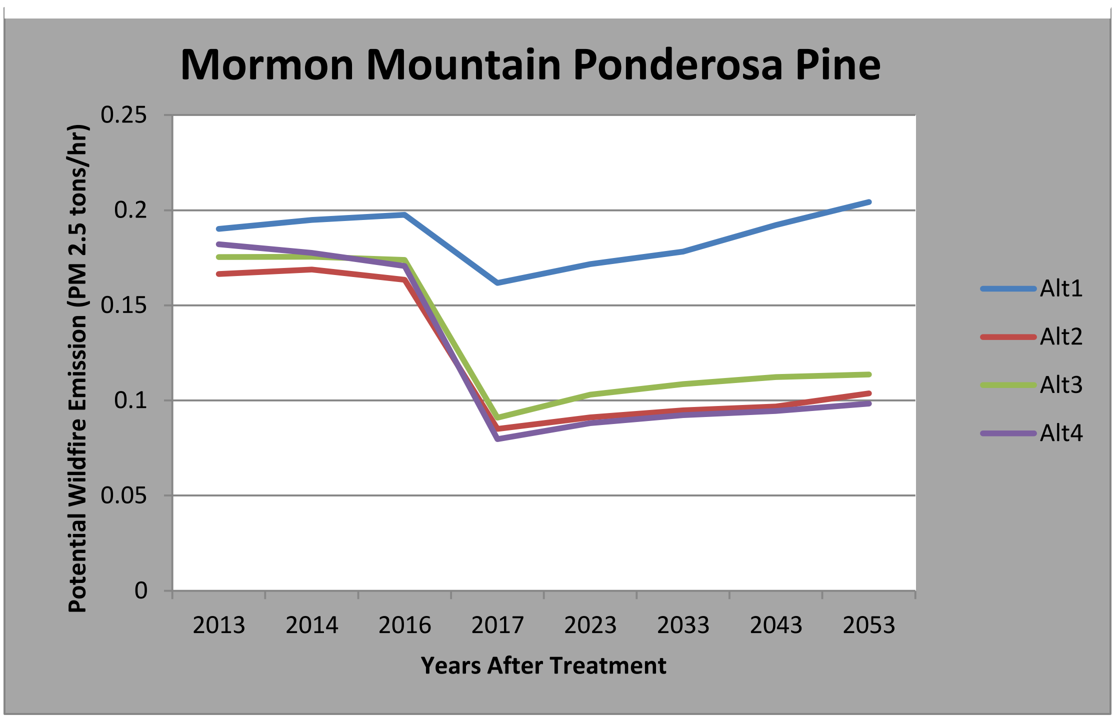


Figure 5: Predicted reductions in potential wildfire emission of PM 2.5 per alternative Mormon Mountain



Cumulative effects

The cumulative effects boundary for this analysis is defined as the area contained within the Little Colorado River airshed, the Kachina Peaks Wilderness and the Verde River airshed.

Forest health and fuel reduction projects that have occurred in close proximity to the FWPP area have most likely helped with reducing the potential effects of wildfire on the above named airsheds. These fuel reduction projects include Wing Mtn. Hart Prairie, Ft. Valley, A-1, Lake Mary Fuel Reduction, Skunk Fuel Reduction, East Side, and Woody Ridge. However, by not treating FWPP itself, the project area and surrounding untreated forested areas would most likely experience damaging fire effects and produce great quantity of smoke emissions if a wildfire entered into the untreated area under extreme weather conditions.

According to the Flagstaff Zone Dispatch, the Coconino National Forest averages about four hundred wildfires a year. Roughly half of these are human-caused, with the balance caused by lightning. On average there are eighty-five days a year in which multiple wildfires start. The vast majority of these fires are controlled at one-tenth of an acre. Large destructive fires increase the average annual wildfire acres up to four thousand acres a year. Smoke from a wildfire occurring under modeled conditions would exceed air quality standards. As more area is left untreated on the forest, smoke from a wildfire occurring under the No Action Alternative could accumulate with emissions from other wildfires and further exceed air quality standards.

Alternatives 2, 3 &4

Direct and Indirect Effects

Alternatives 2, 3, and 4 seek to reduce the fire hazard while retaining as many nutrients on site as possible. For the Dry lake Hills,(Alternatives 2 and 3), prescribed burning is proposed for approximately 5,963 acres of piled slash, and surface fuels on the forest floor using broadcast burning techniques. Alternatives 2, 3, and 4 propose prescribed fire and pile burning on 2,975 acres in the Mormon Mountain unit. Alternative 4 proposes prescribed fire and pile burning on 3,459 acres for Dry Lake Hills. A direct effect of all of the action alternatives is that smoke from prescribed burning will have short-term impacts on local air quality. These effects come from three sources: 1) pile burning of slash generated from thinning; 2) initial entry broadcast burning of the forest floor and; 3) maintenance broadcast burning.

A direct effect of all the alternatives is that smoke from prescribed burning would have short-term impacts on local air quality. These effects come from three sources: 1) pile burning of slash generated from thinning trees, 2) initial entry broadcast burning of the forest floor, and 3) maintenance broadcast burning of the forest floor. Emissions generated by these actions have been modeled using FVS for the project and are found in the proposed treatments per alternative tables (Table 14 and Table 15 for Alternative 2; Table 24 and Table 25 for Alternative 3; and Table 28 and Table 29 for Alternative 4).

Prescribed Fire Effects

Slight differences in prescribed fire effects (flame length, scorch height, mortality and downed woody debris) are also evident between Alternatives 2 and 3. This is because Alternative 3 would leave slightly more material on the ground post-implementation compared to Alternative 2 due to the differences in harvesting methods.

Pile Burning

Pile-burning is relatively efficient combustion producing fewer emissions than both wildfires (pre-treatment) and initial entry prescribed burning. An ‘initial entry’ fire is a fire that burns though an area that has not had fire for at least a couple of decades. A result of decades of fuel buildup is a greater volume of emissions per area. Subsequent fires (wildfires or prescribed fires) have less fuel to burn and produce fewer emissions per area. A direct effect of action alternatives (2, 3, and 4) is that some smoke from pile burning may still subside into the neighborhoods in and around the project area after most of the piles have burned down to 10 % or less of their original size. Pile burning near subdivisions may cause short-term smoke impacts, usually lasting at the most a day.

Broadcast Burning

The initial prescribed burning of the forest floor produces more emissions than pile burning, but far less than most wildfires burning in the same (pre-treatment) fuel bed (compare Table 12and Table 13 to Table 14and Table 15, for example). The initial broadcast burning of each block in the project area would generate smoke for as long as seventy-two hours after ignition. The emissions from implementing would generally meet National and State Ambient Air Quality Standards because burning would only occur under weather conditions that are favorable for burning and on a certain number of acres of land that would reduce smoke impacts to surrounding areas.

Once initial entry burning has occurred, successive maintenance burns would be implemented every five to seven years in the ponderosa pine to mimic the historic fire regime. These maintenance burns would generate less smoke volume, be shorter in duration, and have less smoke after sunset compared to that created by an initial prescribed burn and far less than that created by a wildfire.

The high level of recreation activity that occurs in the summer months in and around the DLH area is not likely to be impacted by smoke because very little to no prescribed burning would be conducted during the summer. Recreationists visiting the project area and surrounding areas in the fall and spring could be impacted by smoke from prescribed burning. The smoke impact could last for as long as seventy-two hours during initial entry broadcast burning, but usually only six hours during maintenance burning.

Smoke plume trajectories indicate that the communities within and adjacent to the project area and Highway 180 and Lake Mary RD may be impacted by smoke when burning. Short-term air quality degradation and reduced visibility may be experienced. After sunset, cooling atmospheric conditions would carry smoke down drainages. These down-canyon flows typically reach the communities around the project area in the early morning hours.

The early morning flows may carry smoke down slope and reduce visibility in surrounding low lying areas when blocks adjacent to these areas are being burned. These portions would be posted with appropriate signs warning residents living adjacent to the project area, forest visitors, and motorists of reduced visibility. Ignition of each day’s block would be completed in the afternoon, thus limiting the smoke generated after atmospheric cooling begins. Smoke impacts would be much worse should a wildfire occur under modeled weather conditions without the implementation of the proposed action. These impacts are shown in Figure 6

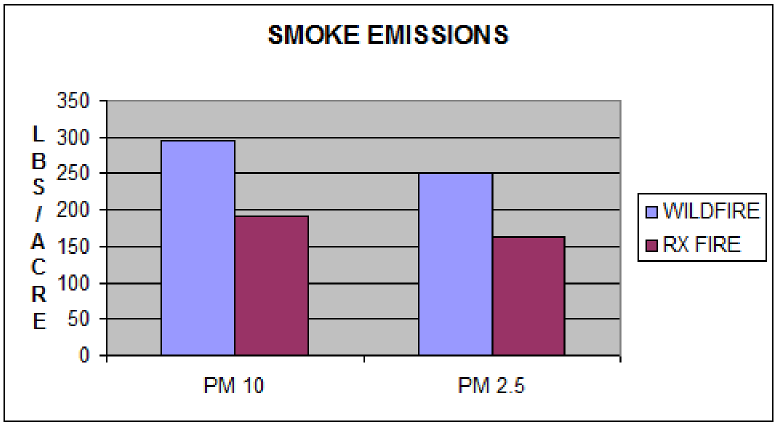


Figure 6: General Smoke Emissions for a particulate matter[2] 10 and 2.5 for prescribed fire and wildfire on the Coconino NF

The reduction in the fuel load and the increased openness of the canopy would allow future broadcast burning under a wider range of weather conditions than the existing conditions. The ability of fire managers to limit undesirable smoke impacts is increased by having a wider range of weather parameters within which to burn. Areas that have been thinned mechanically would allow a wider range of weather conditions than unthinned forested areas, and would have a lower risk of smoke impacts because the canopies have been opened up, allowing for better ventilation and smoke dispersal. Forested areas thinned by hand would allow the next widest range of areas determined to need thinning. Areas receiving burn only treatments may or may not have an open canopy depending on their existing condition. Burning in stands that are not thinned and have high canopy closures will most likely produce the heaviest smoke impacts. Potentially heavy smoke impacts would be avoided by burning on days with favorable ventilation as regulated by the Arizona Department of Environmental Quality (ADEQ).

Cumulative effects

The cumulative effects for air quality for the project, the area contained within the Little Colorado River airshed, Kachina Peaks Wilderness and the Verde River airshed were considered.

Smoke emitted from a wildfire occurring after treatment under alternative two would be unlikely to exceed air quality standards by itself. However, it could combine with the emissions of other wildfires that may be burning simultaneously in the same airshed. The accumulation of smoke from multiple wildfires inside and outside the project area might exceed air quality standards, which would serve as a cumulative effect for this project.

The other fuel reduction projects that are currently being implemented adjacent to the FWPP area also include burning activities, which may affect the Little Colorado River and Verde River airsheds (Hart Prairie, Ft. Valley, A-1, Lake Mary Fuel Reduction, East Side, Woody Ridge, Mormon Lake Basin, Mint, Rocky, Munds Park, Mountainaire, Marshall, Elk Park and Kachina). However, the purpose of ADEQ regulation of daily burning in multiple areas within an airshed is to limit smoke impacts to that and any adjacent airsheds.

[2] Particulate matter consists of inhalable coarse particles (>2.5 and <10 micrometers) and fine particles (=<2.5 micrometers in diameter) (http://www.epa.gov/pm/)

Since ADEQ limits the total number of acres burned per day per airshed through the amount of burn approvals issued on a daily basis, daily emissions from prescribed burning do not accumulate to exceed air quality standards. The number of days per year in which prescribed burning occurs is likely to increase as projects are implemented, but exceeding air quality standards would not be an effect due to ADEQ daily approval burning limits. Furthermore, these projects combine to reduce future smoke impacts.

Smoke from pile burning may combine with smoke from wood-burning stoves and automobile smoke on some days when inversions are strongest during the winter.

In sites with more closed canopies, forest floor fuel accumulates more quickly. In sites where canopies are denser, prescribed burning can only be executed under a narrower window of weather conditions. Thus, denser canopies result in fewer opportunities to prescribe burn. In turn, fuel accumulates on the forest floor when not burned frequently; thereby resulting in greater smoke impacts than when burning conditions can be met and prescribed burning of the fuel bed takes place.

Monitoring Recommendations

In the last two years, Flagstaff Ranger District fuels personnel have started to monitor the effects of prescribed burning in different project areas. The protocols used and variables measured to monitor pre and post treatment are included in Appendix 5.

Laws, Regulations and Policy affecting Fuels treatments and Air Quality

National Level Direction

Federal laws, regulations, and policies affecting this project include:

- <u>Executive Order 13112; Invasive Species</u> (64 FR 6183, February 8, 1999). The FWPP proposes ground disturbing activities, such as mechanical thinning, and prescribed fire which may provide opportunities for invasive species to become established. To comply with this Executive Order, FWPP would monitor populations within the treatment area, and restore native species and habitat conditions in areas that are invaded.

- <u>Organic Administration Act, June 4, 1897 (16 U. S. C. 551)</u>. This act authorizes the Secretary of Agriculture to make provisions for the protection of national forests against destruction by fire. The treatments proposed by FWPP would support the intent of the Organic Administration Act by reducing the potential for undesirable fire behavior and effects.

- <u>National Environmental Policy Act of 1970</u>. Compliance with this act requires analysis of proposed actions. Proposed treatments include prescribed fire and mechanical treatments, so the analysis includes the effects of prescribed fire as well as the resulting emissions.

- <u>Clean Air Act (CAA), as amended 1977 and 1990</u>. This act provides for the protection and enhancement of national air resources by regulating air emissions from stationary and mobile sources. This law authorized EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and welfare and to regulate emissions of hazardous air pollutants. NAAQS were established for specific pollutants emitted in significant quantities throughout the country that may be a danger to public health and welfare. If an area does not meet or “attain” the standards, it becomes a non-attainment area and must demonstrate to the public and the EPA how it will meet standards in the future via a State Implementation Plan (SIP). Section 112 of the CAA addresses emissions of hazardous air pollutants, including smoke from wildfires and prescribed fires. Section 160 of the CAA requires measures “to preserve, protect, and enhance the air quality…” in national parks, national wilderness areas, national monuments, and other areas of special national or regional natural, recreational, scenic, or historic value, some are classified as Class I attainment areas. Implementation of the CAA is largely the responsibility of the states which may develop programs that are more restrictive than the CAA requires but never less. The CAA mandates states have a SIP to regulate pollutants. The FWPP proposes using prescribed fire on 8,938 acres. To ensure compliance with the CAA, emissions from these acres were evaluated to determine the potential effects.

The “1995 Federal Wildland Fire Policy” is the principle document guiding fire management on Federal lands. The Policy was endorsed and implemented in 1995. The 1995 Federal Wildland Fire Policy was reviewed and updated in 2001 (Review and Update of the 1995 Federal Wildland Fire Management Policy, 2001). In 2003 the Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy was approved. The 2003 Implementation Strategy was replaced in 2009 with the adoption of the Guidance for Implementation of Federal Wildland Fire Management Policy which states that:

“Fire, as a critical natural process, will be integrated into land and resource management plans and activities on a landscape scale, and across agency boundaries. Response to wildland fire is based on ecological, social, and legal consequences of fire. The circumstances under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and values to be protected dictate the appropriate management response to fire.”

The FWPP is not intended to dictate the appropriate response to wildfires. Action alternatives should increase the decision space for Agency Administrators for how to manage lightning caused fires when they occur, while reducing the potential for undesirable fire behavior and effects. The effects of planned ignitions (prescribed fires) are discussed. This document provides direction, consistent with the Coconino Forest Plan regarding the use of planned ignitions in the proposed treatment area.

State Level Direction

Arizona Department of Environmental Quality (ADEQ) air quality regulations: Smoke produced by prescribed fires is subject to regulation by EPA regulations as enforced by the ADEQ. The State of Arizona has a State Implementation Plan that outlines how the State is implementing the goals of the Clean Air Act, and Statutes that regulate burning, including burning on Federal lands. Two types of air quality impacts are addressed by these laws and regulations: health hazards from pollutants, and potential visibility impacts in Class I Air Sheds.

The key policy resulting from the Enhanced Smoke Management Plan pertaining to prescribed burns in Arizona is Arizona Revised Statute Title 18 Chapter 2 Article 15. This law regulates fires managed on Federal and State lands, as well as on Tribal, private, and municipal jurisdictions where there is a Memorandum of Understanding with the Arizona Department of Environmental Quality (ADEQ). This Statute defines the request and approval process for all burns, and provides the mechanisms for tracking emissions from burns. Enforcement of this statute is facilitated by the Smoke Management Group, housed at ADEQ in the Air Quality Division. Prescribed fires implemented as treatments under the FWPP will be subject to these same regulatory policies and statutes and meet the Enhanced Smoke Management Plan. The State of Arizona has an Enhanced Smoke Management Plan (ESMP) that is consistent with the Western Regional Air Partnership (WRAP) Enhanced Smoke Management Programs for Visibility. The State of Arizona conducts annual meetings of all affected parties to discuss smoke management issues and objectives. This approach calls for programs to be based on the criteria of efficiency, economics, law, emission reduction opportunities, land management objectives, and reduction of visibility impacts. An Enhanced Smoke Management Plan (ESMP) comprises a series of key policies and management practices. In general the ESMP must specifically address visibility effects and apply to all fire sources as do all smoke management plans in the State of Arizona. The ESMP should also apply uniformly to source sectors or be tailored to source sectors and/or geographical areas. In addition, the ESMP must provide the opportunity to work collaboratively with state, tribal, local, and federal agencies, and private parties while considering the criteria of efficiency, economics, law, emission reduction opportunities, land management objectives, and reduction of visibility impact.

Problem or Nuisance Smoke is defined by the Environmental Protection Agency (EPA) as the amount of smoke in the ambient air that interferes with a right or privilege common to members of the public, including the use or enjoyment of public or private resources. While there are no laws or regulations governing nuisance smoke, it can limit opportunities of land managers to use fire. Public concerns regarding nuisance smoke often occur long before smoke exposures reach levels that violate NAAQS (Achtemeir et al. 2001). "Probably the most common air quality issues facing wildland fire managers are those related to public complaints about nuisance smoke...about the odor or soiling effects of smoke, poor visibility, and impaired ability to breathe or other health-related effects. Sometimes complaints come from the fact that some people don't like or are fearful of smoke intruding into their lives (Hardy et al. 2001b)." Prescribed fire treatments proposed though the action alternatives may result in an increase of Nuisance Smoke.

Agency Level Direction

USDA Forest Service

Forest Service Manual 5100 (page 9) includes direction on USFS use of prescribed fire to meet land and resource management goals and objectives. The objectives of fire management on lands managed by the USFS are:

1. Forest Service fire management activities shall always put human life as the single, overriding priority.

2. Forest Service fire management activities should result in safe, cost-effective fire management programs that protect, maintain, and enhance National Forest System lands, adjacent lands, and lands protected by the Forest Service under cooperative agreement.

Coconino National Forests' Land & Resource Management Plan (LRMP)

Forest Plans provide specific goals, objectives, standards, and guidelines for management activities on National Forest lands. The Coconino National Forest (USDA 1987, as amended 2012) has developed forest-wide and location-specific standards and guidelines for reducing the risk of severe fire effects to resources.

The forest plans provide specific goals, objectives, standards, and guidelines for management activities on the Coconino National Forest. The forest-wide, management area (MA), or geographic area (GA) standards and guidelines have fire-related (management of or reduced risk to resources values from) relevance to this analysis. Directions for other resources aimed at reducing the risk of fire have been incorporated into this analysis as appropriate.

Appendix 1: References **(Literature Cited)**

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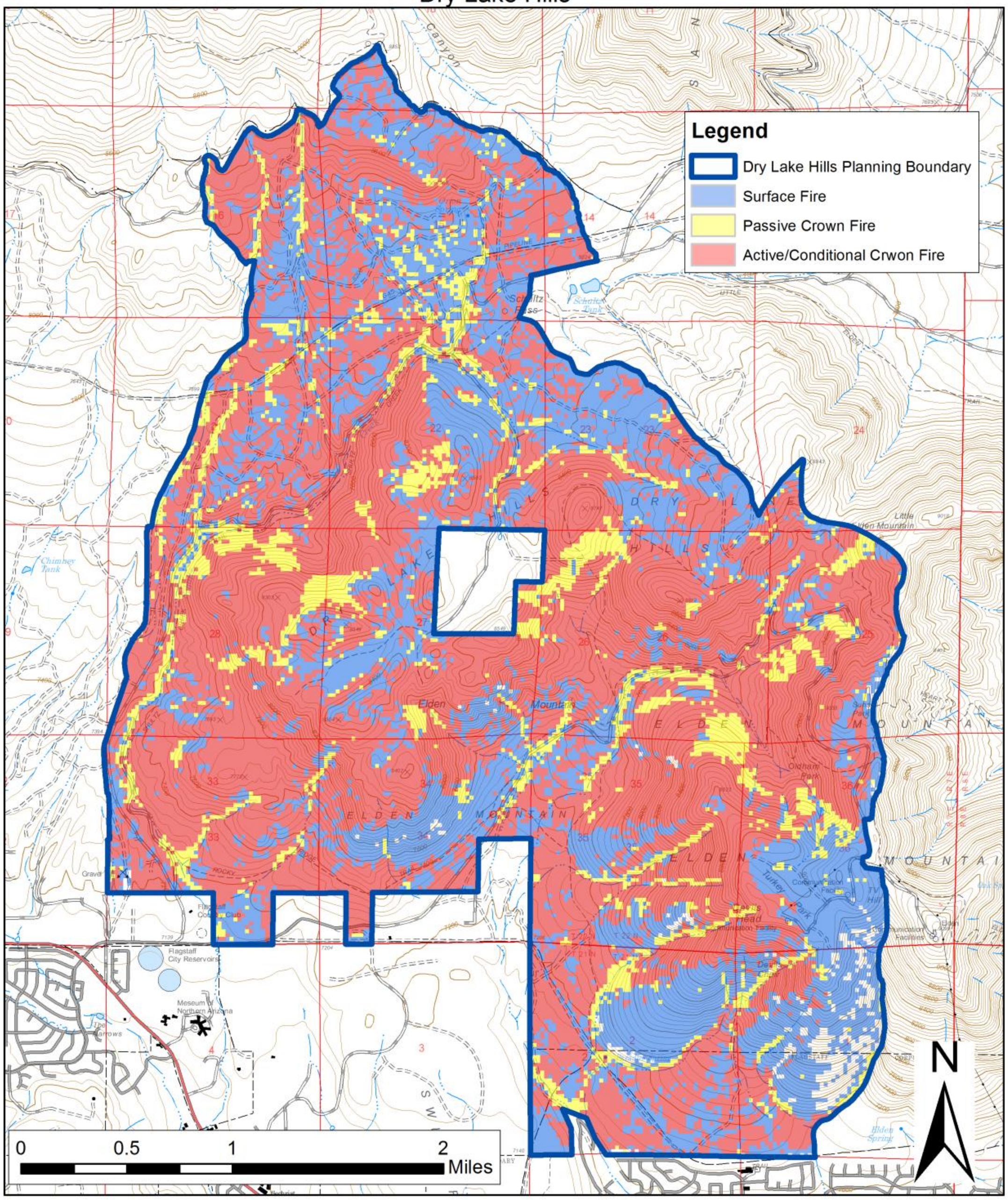
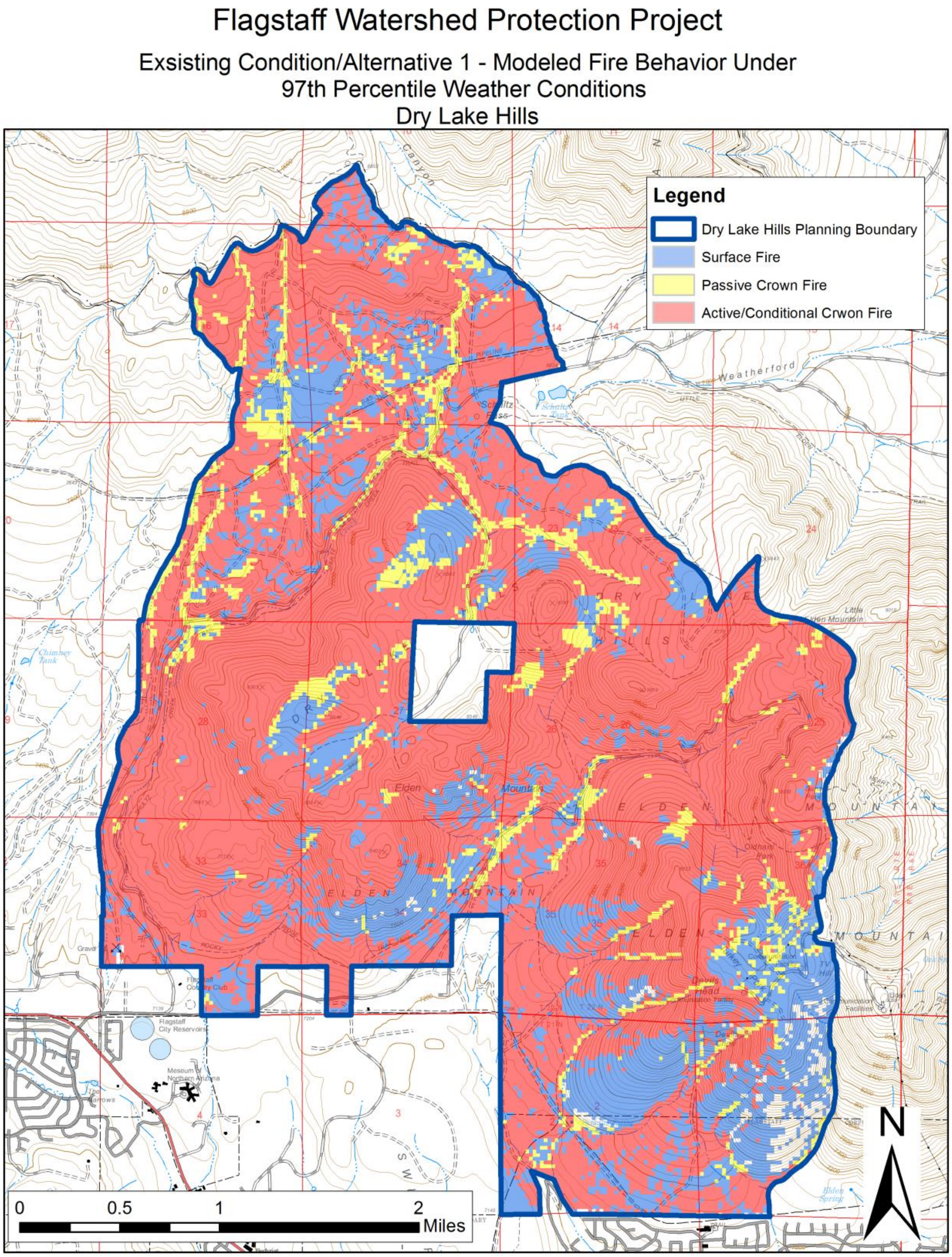
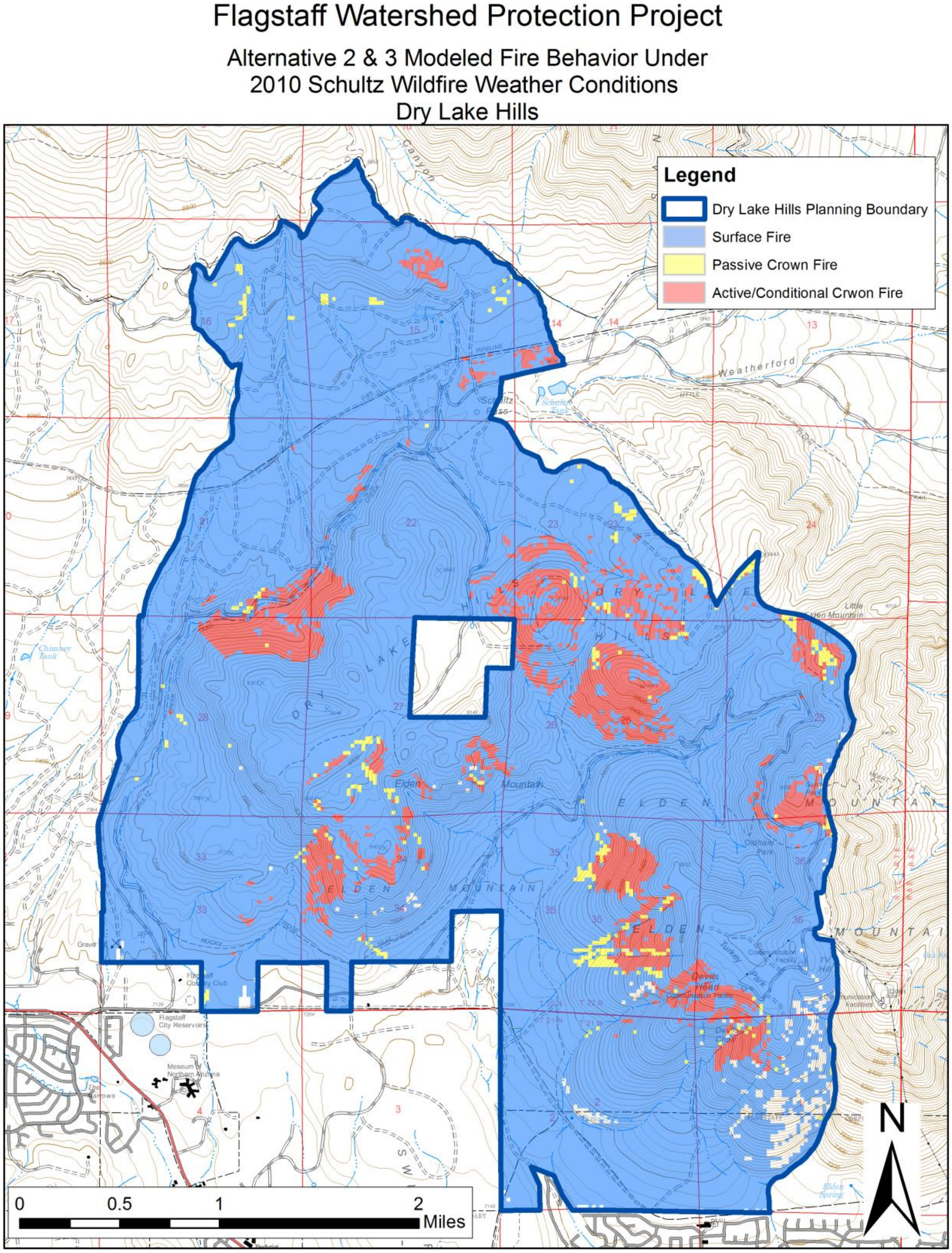
Appendix 2: Crown Fire Potential Maps

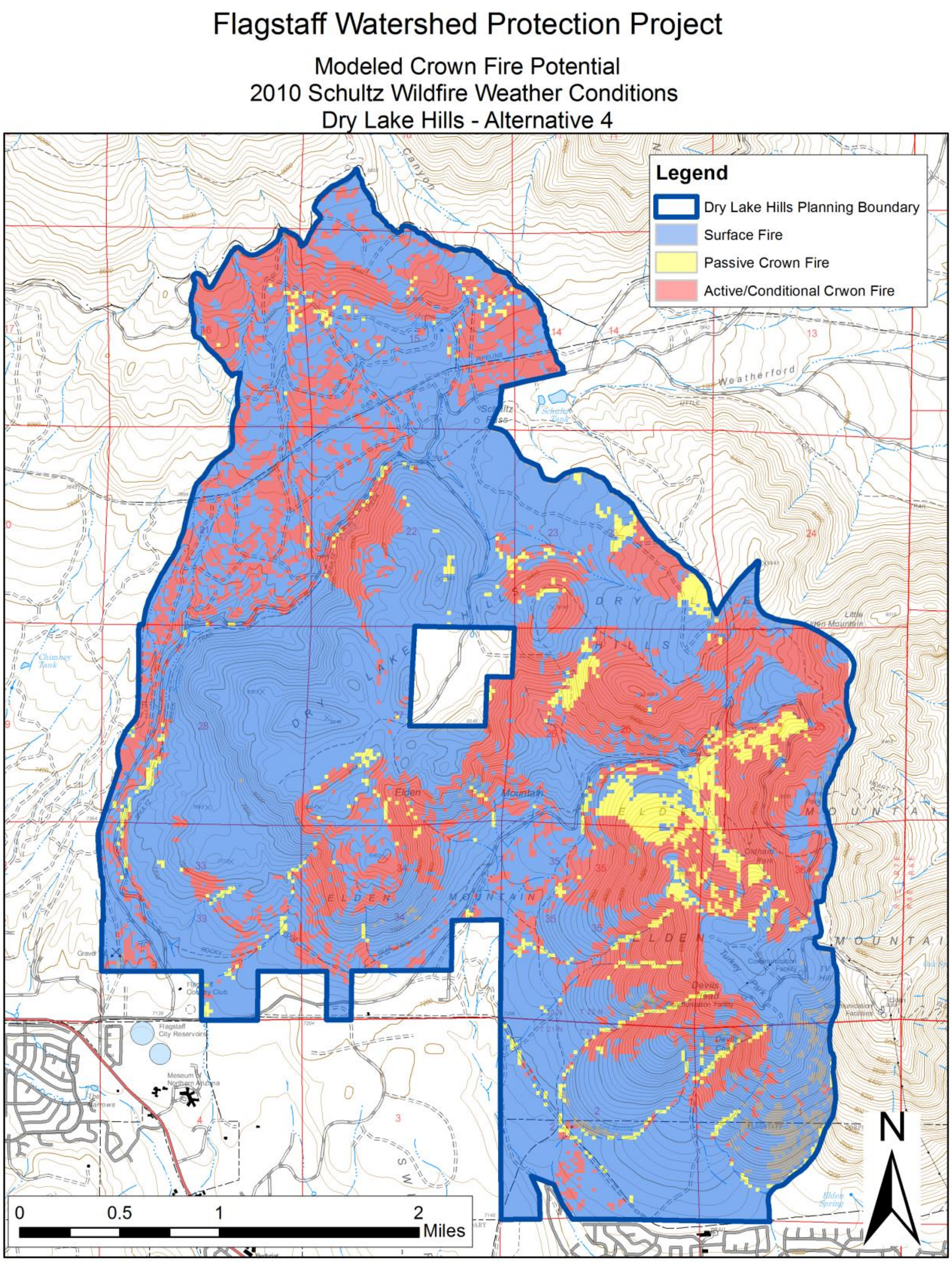
Flagstaff Watershed Protection Project

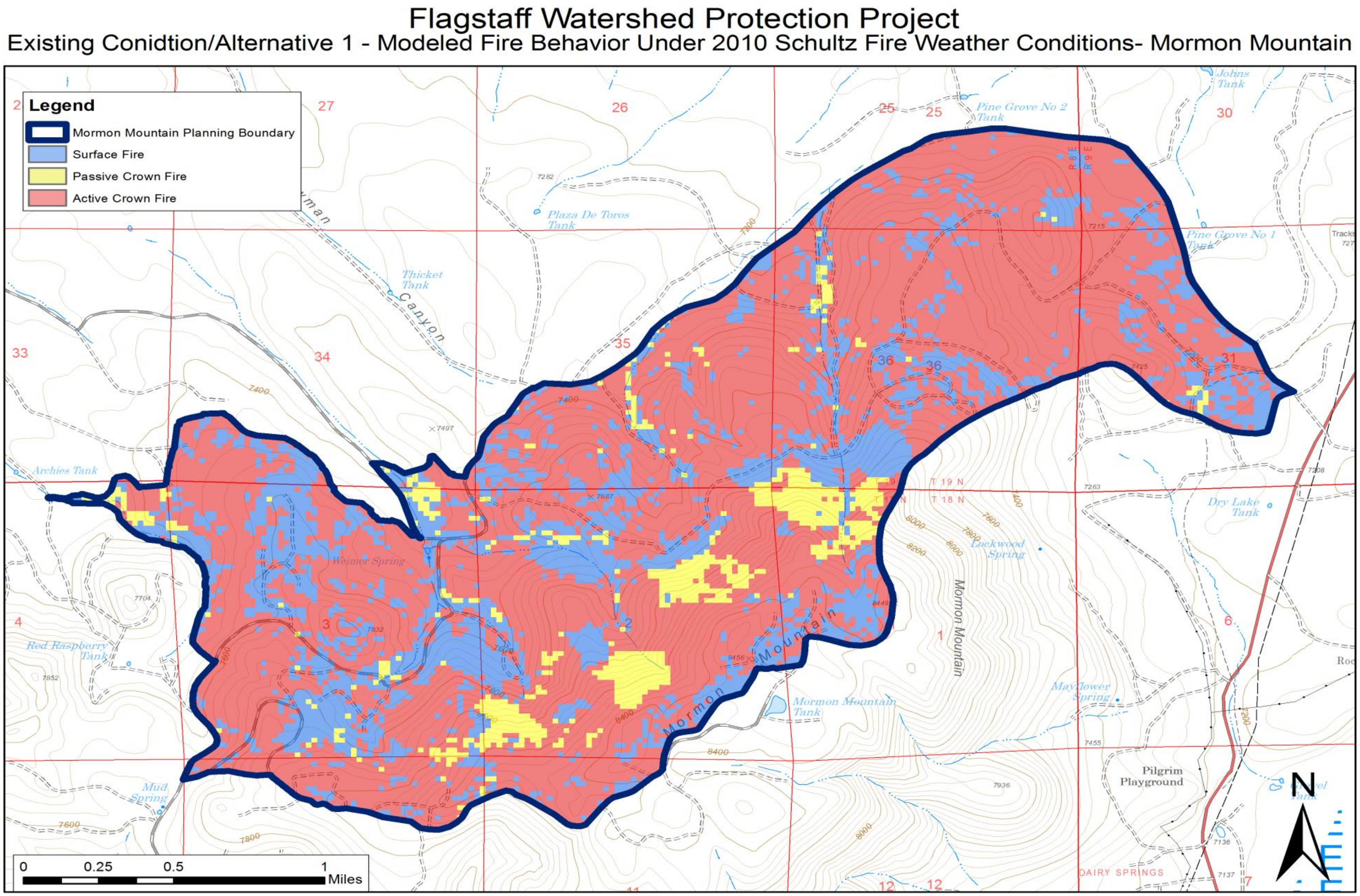
Exsisting Condition/Alternative 1 - Modeled Fire Behavior Under
2010 Schultz Wildfire Weather Conditions
Dry Lake Hills




Flagstaff Watershed Protection Project
Exsisting Condition/Alternative 1 - Modeled Fire Behavior Under
97th Percentile Weather Conditions
Dry Lake Hills
Legend
Dry Lake Hills Planning Boundary
Surface Fire
Passive Crown Fire
Active/Conditional Crwon Fire
0
0.5
1
2
Miles
N

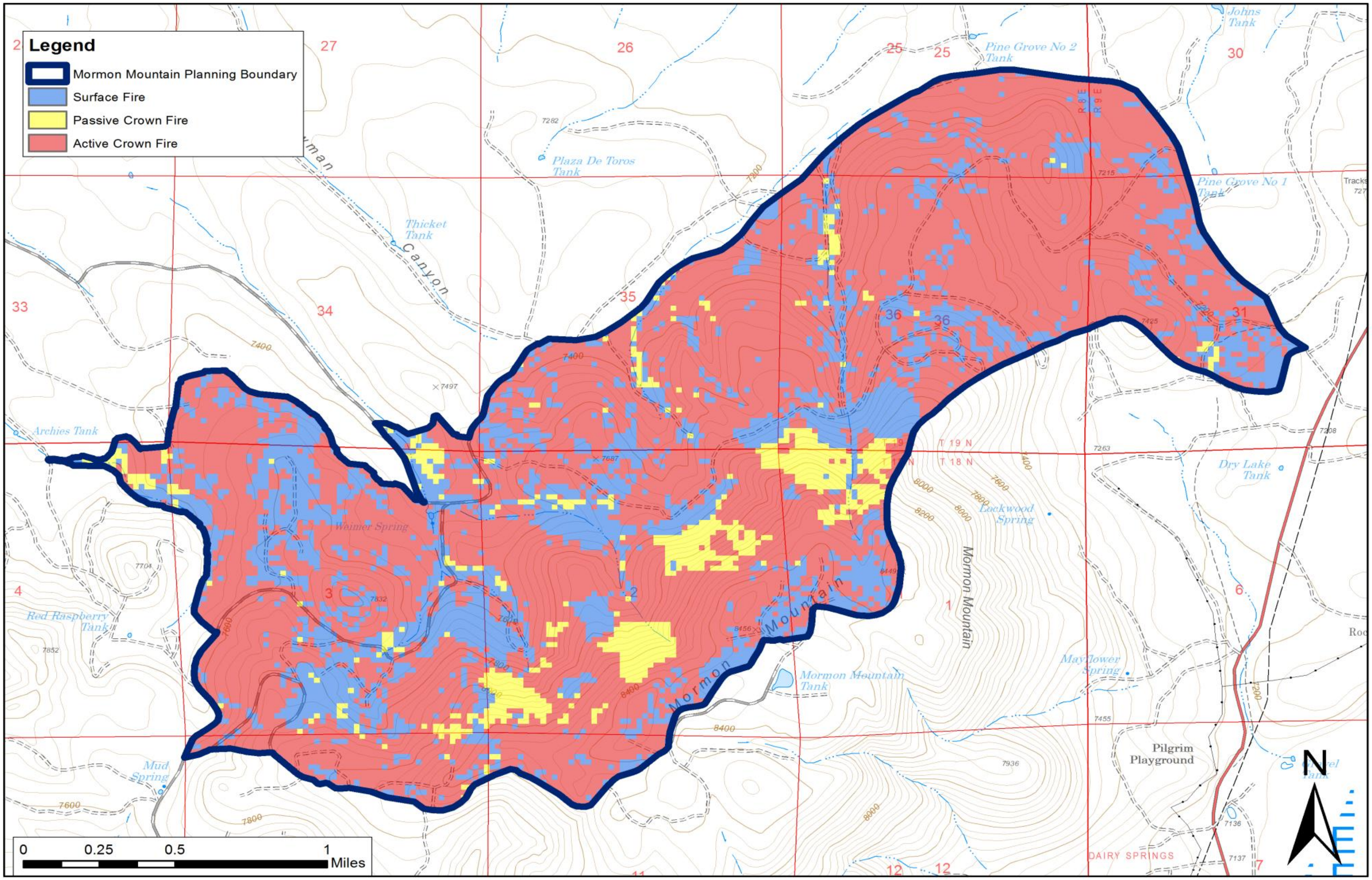

Flagstaff Watershed Protection Project
Alternative 2 & 3 Modeled Fire Behavior Under
2010 Schultz Wildfire Weather Conditions
Dry Lake Hills
Legend
Dry Lake Hills Planning Boundary
Surface Fire
Passive Crown Fire
Active/Conditional Crwon Fire
0
0.5
1
2
Miles
N


Flagstaff Watershed Protection Project
Modeled Crown Fire Potential
2010 Schultz Wildfire Weather Conditions
Dry Lake Hills - Alternative 4
Legend
Dry Lake Hills Planning Boundary
Surface Fire
Passive Crown Fire
Active/Conditional Crwon Fire
0
0.5
1
2
Miles
N


Flagstaff Watershed Protection Project
Existing Conidtion/Alternative 1 - Modeled Fire Behavior Under 2010 Schultz Fire Weather Conditions- Mormon Mountain
Legend
Mormon Mountain Planning Boundary
Surface Fire
Passive Crown Fire
Active Crown Fire
0
0.25
0.5
1
Miles
N
Mormon Mountain
Mormon Mountain Tank
Lockwood Spring
Pilgrim Playground
Dry Lake Tank
Pine Grove No 1 Tank
Pine Grove No 2 Tank
Plaza De Toros Tank
Thicket Tank
Canyon
Archies Tank
Red Raspberry Tank
Mud Spring
Weimer Spring
Mayflower Spring
Johns Tank
DAIRY SPRINGS
T 19 N
T 18 N

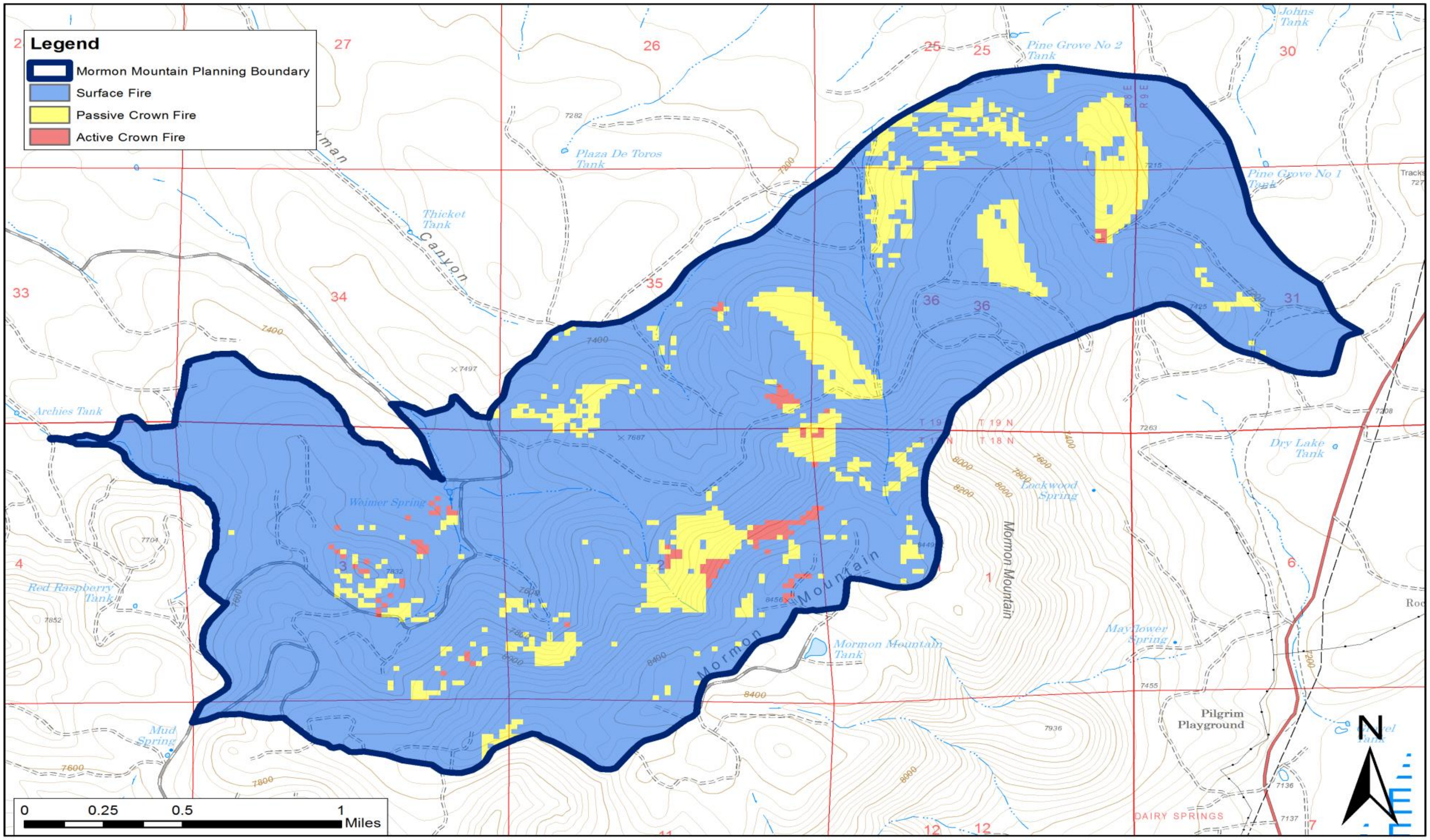
Flagstaff Watershed Protection Project

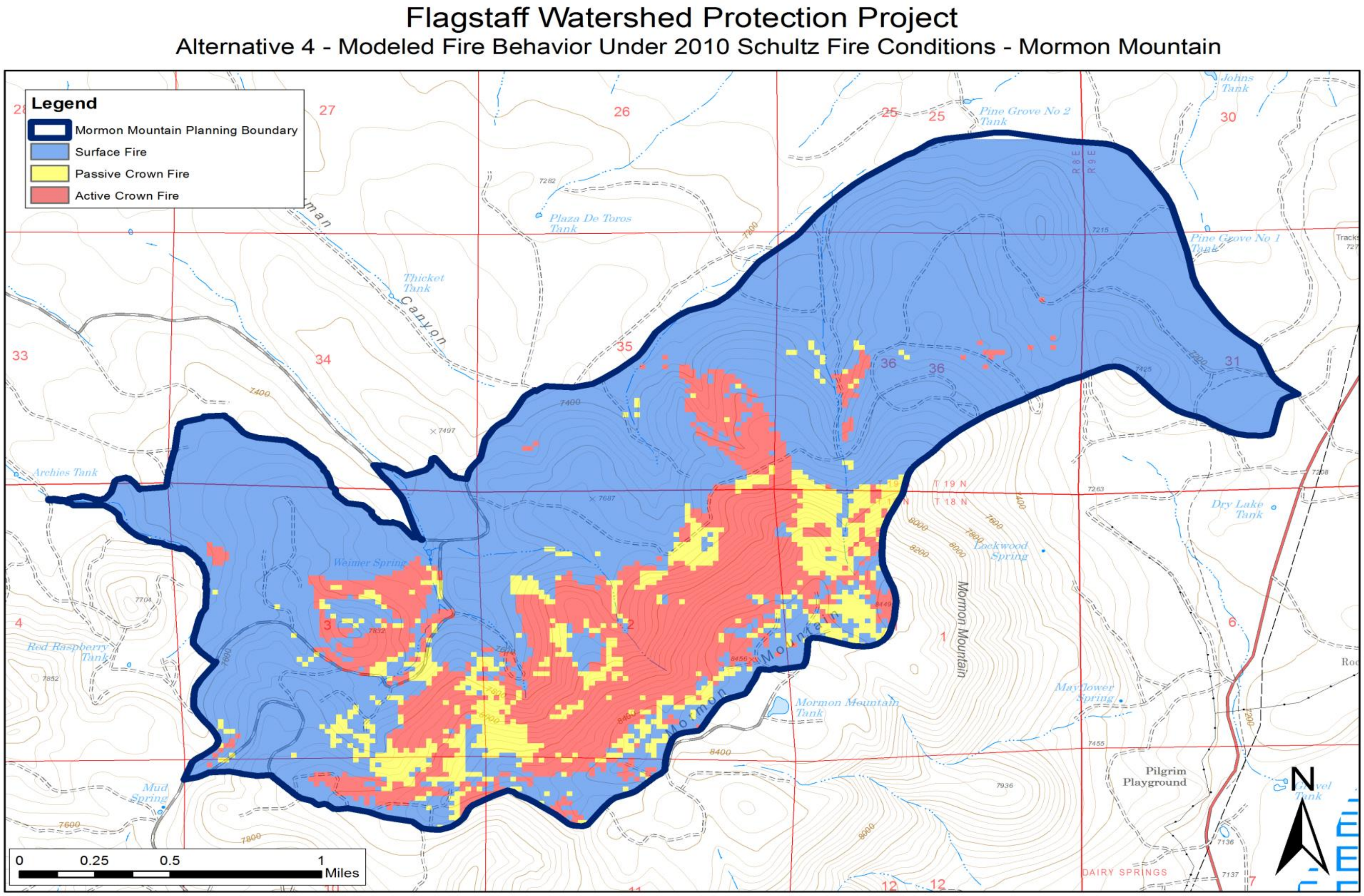
Exsisting Condition/Alternative 1 - Modeled Fire Behavior Under 97th Percentile Weather Conditions - Mormon Mountain



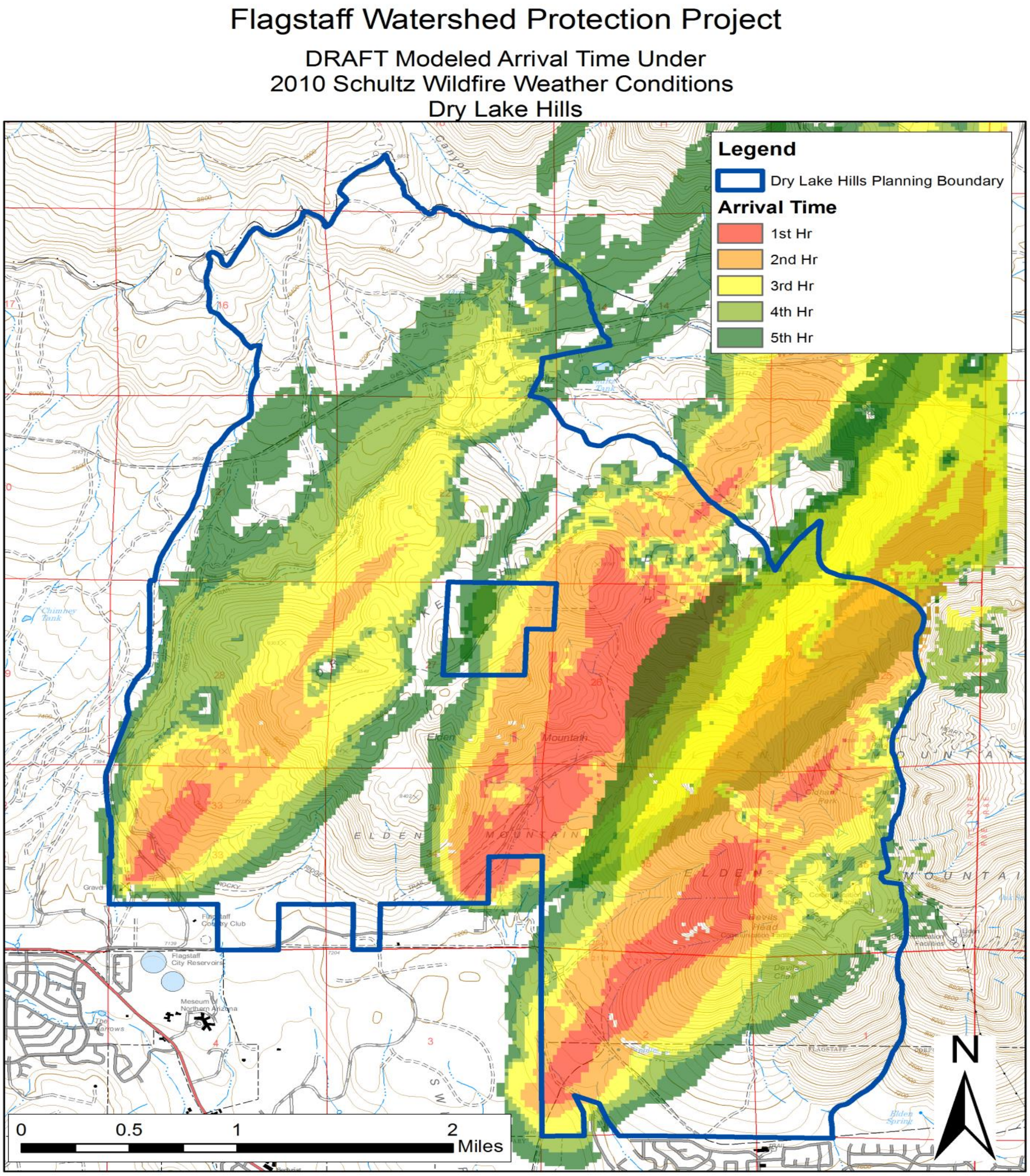
Flagstaff Watershed Protection Project

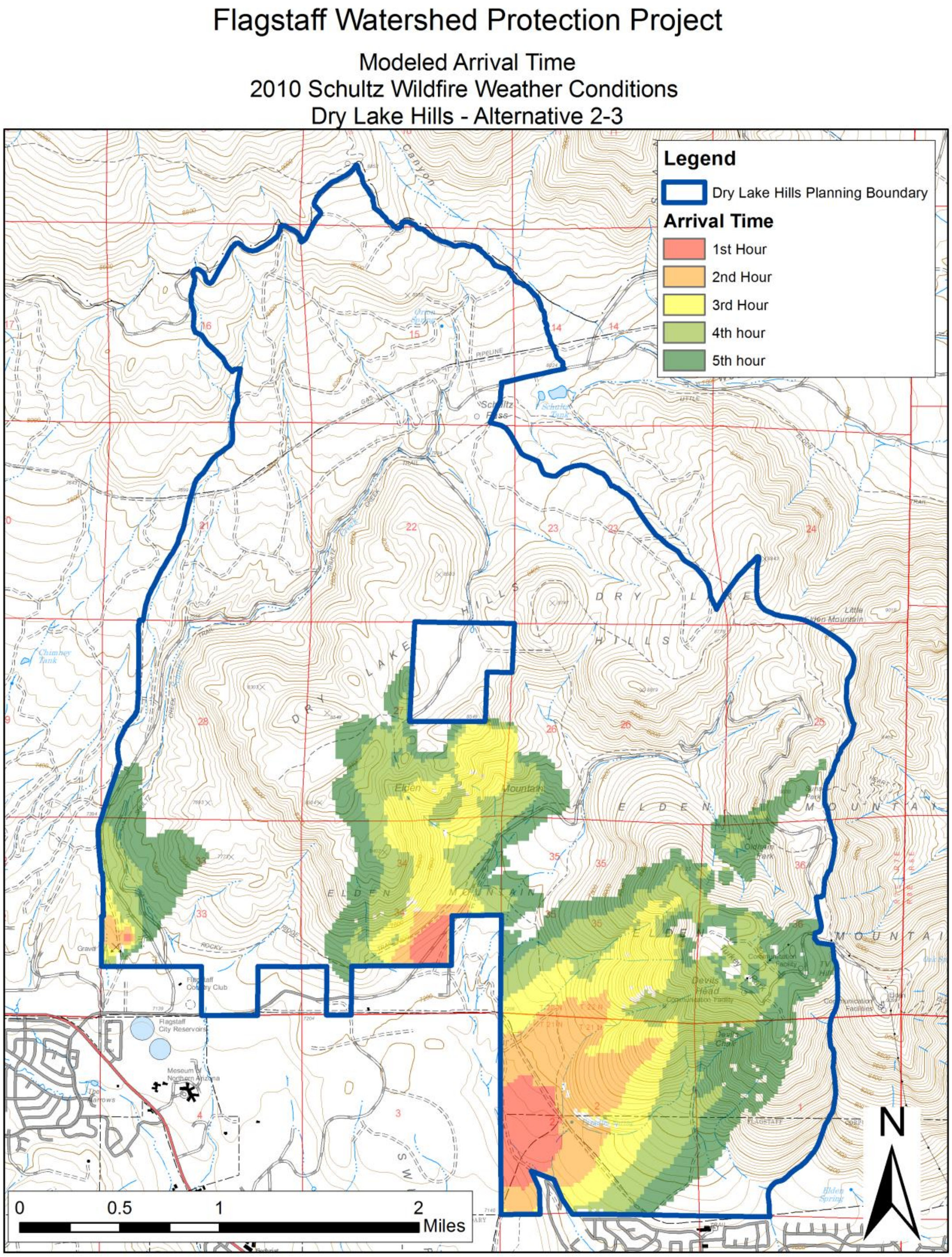
Alternative 2&3 - Modeled Fire Behavior Under 2010 Schultz Fire Weather Conditions - Mormon Mountain




Flagstaff Watershed Protection Project
Alternative 4 - Modeled Fire Behavior Under 2010 Schultz Fire Conditions - Mormon Mountain
Legend
Mormon Mountain Planning Boundary
Surface Fire
Passive Crown Fire
Active Crown Fire
0
0.25
0.5
1
Miles
N
Mormon Mountain
Mormon Mountain Tank
Pilgrim Playground
Dry Lake Tank
Lockwood Spring
Pine Grove No 1 Tank
Pine Grove No 2 Tank
Plaza De Toros Tank
Thicket Tank
Archies Tank
Red Raspberry Tank
Mud Spring
Weimer Spring
DAIRY SPRINGS

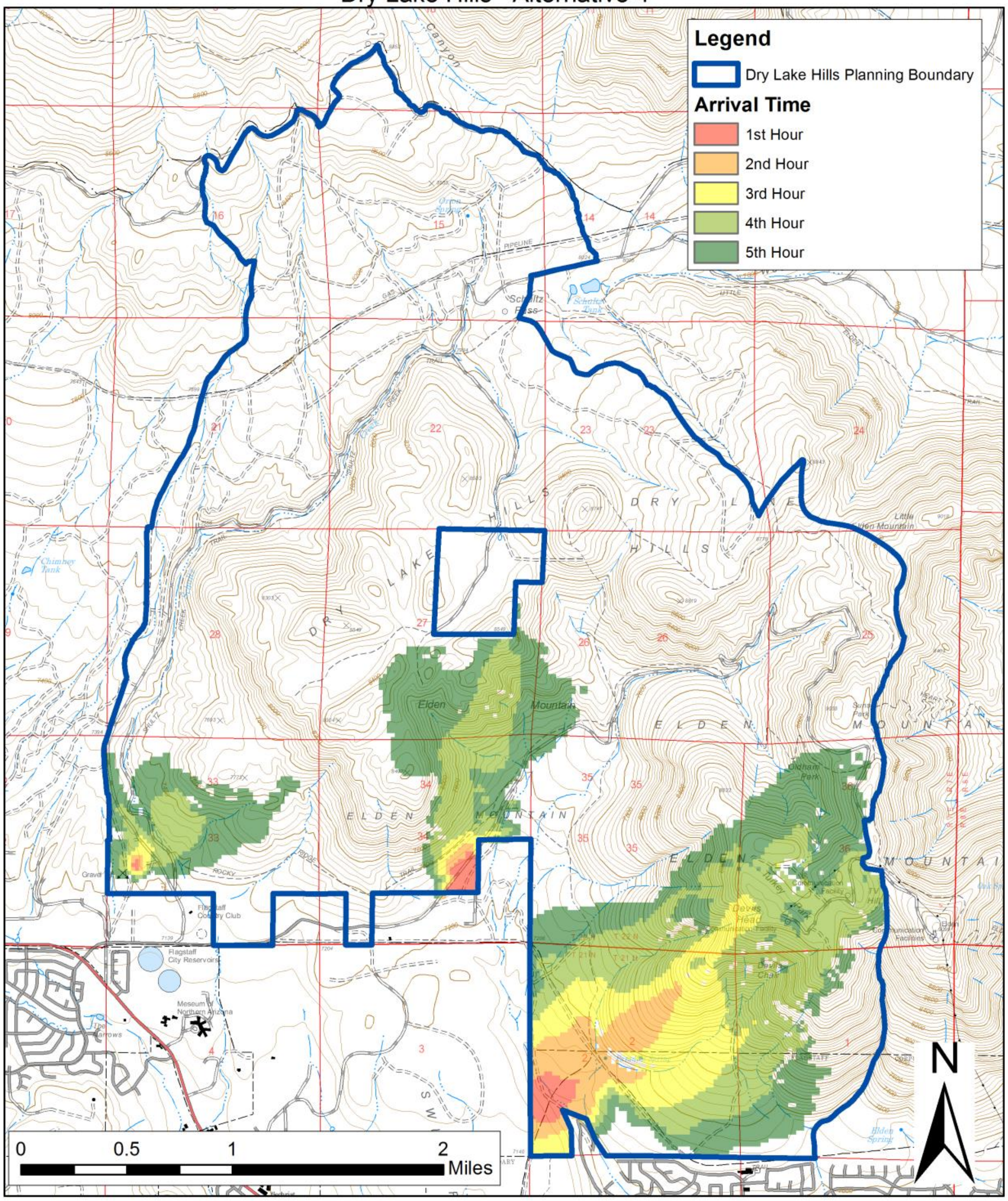
Appendix 3: Arrival Time maps




Flagstaff Watershed Protection Project
Modeled Arrival Time
2010 Schultz Wildfire Weather Conditions
Dry Lake Hills - Alternative 2-3
Legend
Dry Lake Hills Planning Boundary
Arrival Time
1st Hour
2nd Hour
3rd Hour
4th hour
5th hour
0
0.5
1
2
Miles
N

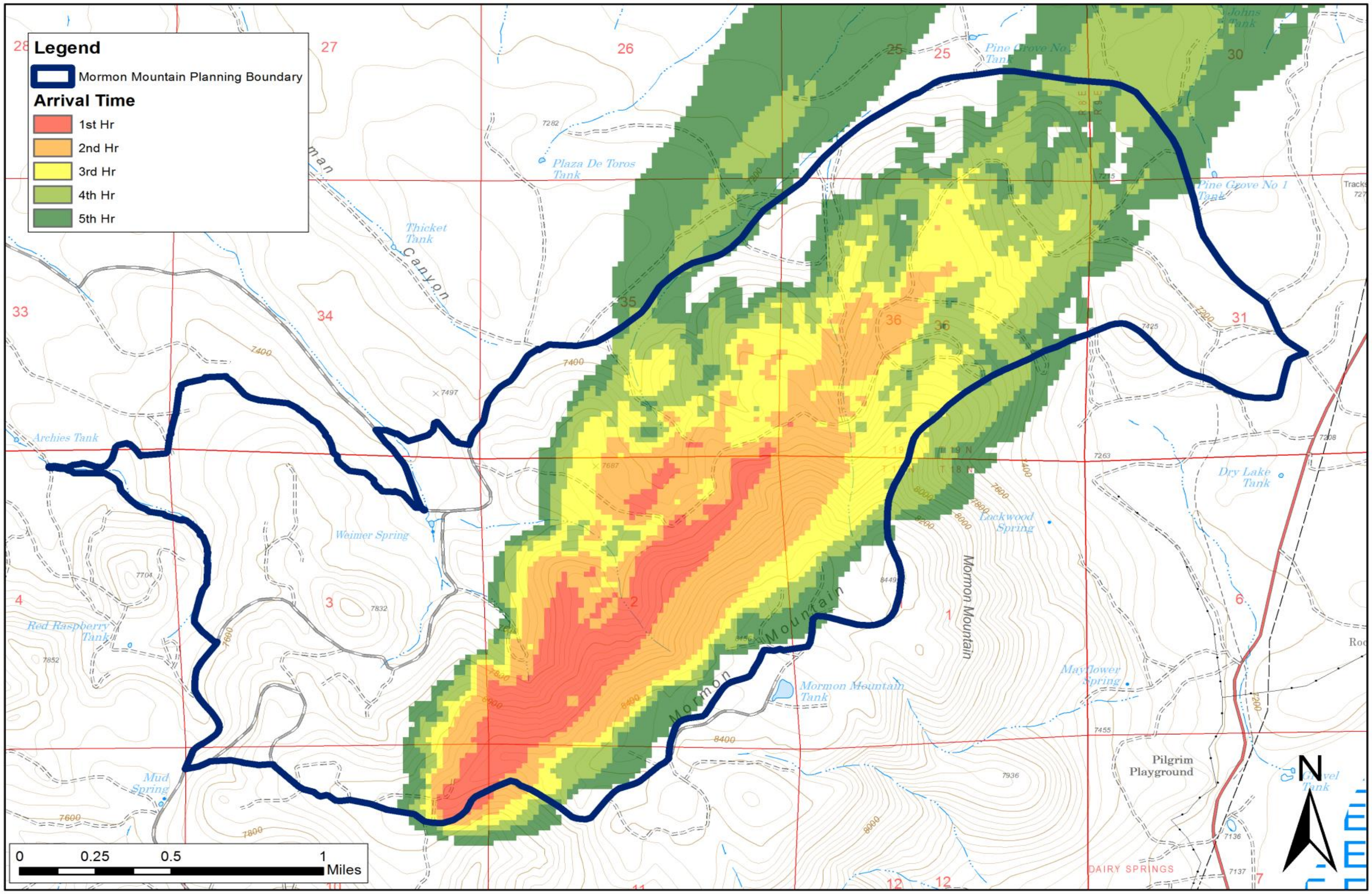
Flagstaff Watershed Protection Project

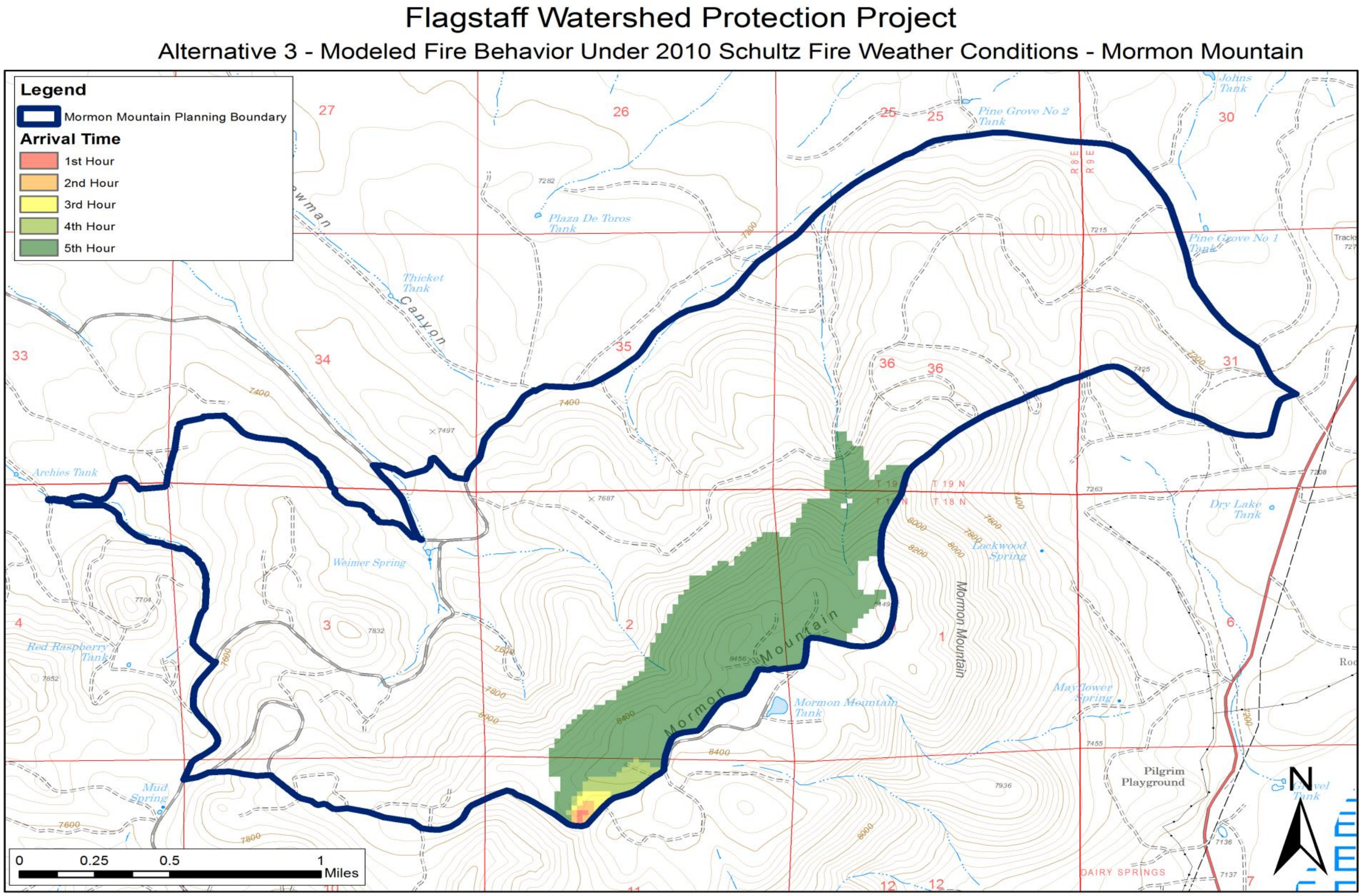
Modeled Arrival Time
2010 Schultz Wildfire Weather Conditions
Dry Lake Hills - Alternative 4



Flagstaff Watershed Protection Project

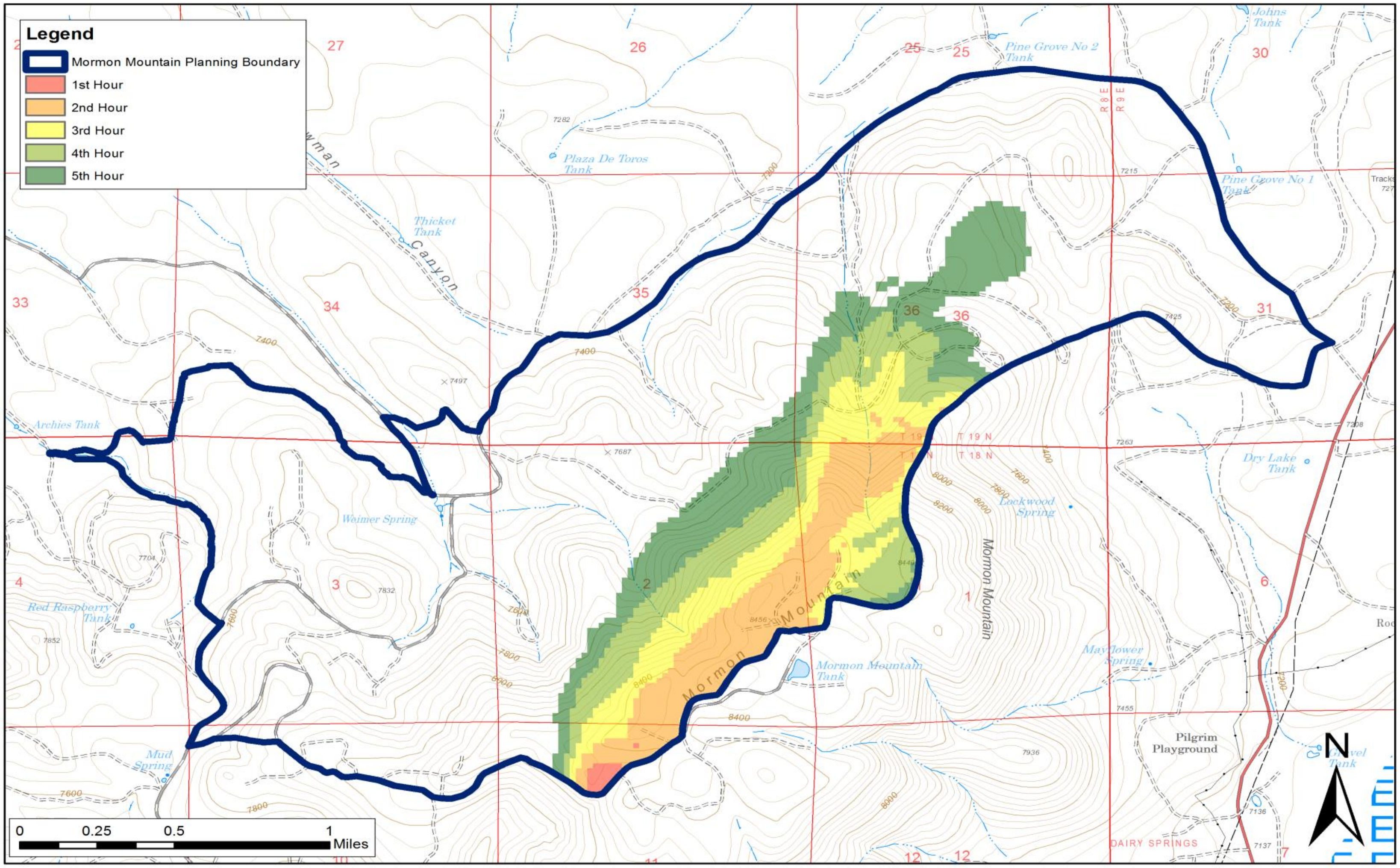
DRAFT Modeled Fire Behavior - Mormon Mountain




Flagstaff Watershed Protection Project
Alternative 3 - Modeled Fire Behavior Under 2010 Schultz Fire Weather Conditions - Mormon Mountain
Legend
Mormon Mountain Planning Boundary
Arrival Time
1st Hour
2nd Hour
3rd Hour
4th Hour
5th Hour
0
0.25
0.5
1
Miles
N
Mormon Mountain
Pine Grove No 2 Tank
Pine Grove No 1 Tank
Plaza De Toros Tank
Thicket Tank
Canyon
Archies Tank
Weimer Spring
Red Raspberry Tank
Mud Spring
Lockwood Spring
Mormon Mountain Tank
Mayflower Spring
Dry Lake Tank
Johns Tank
Pilgrim Playground
DAIRY SPRINGS
T 19 N
T 18 N
R 8 E
R 9 E

Flagstaff Watershed Protection Project

Alternative 4 - Modeled Arrival Time Under 2010 Schultz Fire Conditions - Mormon Mountain



Appendix 4: FVS Fuels Inputs

Keywords/Modifiers Added to FVS:

KeyWord	Parameter	Value
FireCalc	Fire behavior calculations	1=the new fuel models
	Fuel model set	1=use the 40 new Scott and Burgan
	Surface area to volume ration (0-.25)	2000
	Surface area to volume live herb	1800
	Surface are to volume live woody	1500
	Bulk density for live	0.1
	Bulk density for dead fuel	0.75
	Heat content	8000
PotFTemp	Temp for severe fires	85
	Temp for moderate fires	74
PotFWind	20-ft wind speed for severe	32
	20-ft wind speed for moderate	23
PotFSeas	Season for severe fires	3=After greeup (before fall)
	Season for moderate fires	3=After greeup (before fall)
PotFPAB	% of stand burned severe	100
	% of stand burned moderate	100
PotFMois (S)	% moisture 1hr	2
	% moisture 10hr	2
	% moisture 100hr	4
	% moisture 1000hr	6
	% moisture duff	BLANK
	% moisture live woody	65
	% moisture live herb	30
PotFMois (M)	% moisture 1hr	3
	% moisture 10hr	3
	% moisture 100hr	6
	% moisture 1000hr	9
	% moisture duff	BLANK
	% moisture live woody	80
	% moisture live herb	30
FuelOut	Reporting duration	200
	Reporting interval	10
Set Fuel Models	First Fuel Models	Varies by stand
MortRept	Reporting period	200
CycleAt	Year to insert cycle	2016
CycleAt	Year to insert cycle	2017
Prescribed Burn	Schedule by Year/Cycle	2016
	Wind speed @ 20ft	10
	Moisture level	2=Dry
	Temperature	80
	Mortality Code	1=FFE estimates mortality
	% of stand burned	70
	Season of this fire	4=Fall

Fuel Model Assignments by Stand:

Stand	Fuel Models .lcp file	Fuel Model Assigned to FVS
0304020002770012	48%/188, 24%/142, 15%/122, 14%/161	188 (50%), 161 (50%)
0304020002770027	61%/161, 31%/188	188 (50%), 161 (50%)
0304020002980015	53%/165, 27%/188, 18%/161	188 (50%), 165 (50%)
0304020002970015	35%/188, 27%/165, 17%/122, 11%/161	188 (50%), 165 (50%)
0304020002970009	44%/165, 42%/188, 9%/161	188 (50%), 165 (50%)
0304020002870009	37%/188, 34%/165, 26%/161	188 (50%), 165 (50%)
0304020002860017	75%/188, 13%/122, 12%/165	188 (50%), 165 (50%)
0304020002980002	62%/161, 25%/188	188 (50%), 165 (50%)
0304020002670009	37%/188, 36%/161, 16%/165, 8%/122	188 (50%),161 (35%),165 (15%)
0304020002670010	45%/188, 36%/161, 12%/165	188 (50%),161 (35%),165 (15%)
0304020002670016	61%/188, 28%/161	188 (50%),161 (35%),165 (15%)
0304020002670034	38%/188, 32%/161, 28%/165	188 (50%),161 (35%),165 (15%)
0304020002670035	53%/188, 24%/161, 20%/165	188 (50%),161 (35%),165 (15%)
0304020002770023	88%/188, 7%/165	188 (50%),161 (35%),165 (15%)
0304020002770026	51%/165, 29%/188, 20%/161	188 (50%),161 (35%),165 (15%)
0304020002770028	48%/165, 28%/188, 24%/161	188 (50%),161 (35%),165 (15%)
0304020002770030	71%/185, 27%/188	188 (50%),161 (35%),165 (15%)
0304020002770032	64%/161, 22%/188, 10%/165	188 (50%),161 (35%),165 (15%)
0304020002790011	58%/161, 20%/165, 11%/188	188 (50%),161 (35%),165 (15%)
0304020002790013	49%/165, 35%/161, 16%/188	188 (50%),161 (35%),165 (15%)
0304020002870002	60%/165, 33%/188	188 (50%),161 (35%),165 (15%)
0304020002980015	53%/165, 27%/188, 18%/161	188 (50%),161 (35%),165 (15%)
0304020002980015 (Plots)	53%/165, 27%/188, 18%/161	165 (53%), 188 (27%), 161 (18%)
0304020002670015	39%/188, 28%122, 16%/161, 10%/142, 6%/102	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002670033	64%/188, 16%/142, 13%/122, 7%/102	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002770001	39%/188, 37%/165, 15%/161	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002860003	57%/188, 39%/165	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002860004	97%/188	188 (80%), 122 (10%),161 (5%),165 (5%)
0304020002860009	78%/188, 9%/165, 9%/122	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002860016	92%/188, 8%/122	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002860021	97%/188	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002970012	76%/188, 17%/122, 7%/165	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002970002	81%/188, 9%/165, 8%/122	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002970004	69%/188, 27%/122	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002970005	72%/188, 16%/165, 11%/122	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002970013	64%/188, 24%/122, 6%/165	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002980011	78%/161, 10%/188, 6%/102	188 (80%), 122 (10%),161 (5%), 165 (5%)
0304020002870002	60%/165, 33%/188	188 (50%),161 (35%),165 (15%)
0304020002670007	54%/188, 23%/122, 20%/165	188 (70%), 165 (15%), 122 (15%)
0304020002670023	64%/188, 34%/165	188 (70%), 165 (15%), 122 (15%)
0304020002670026	87%/188, 13%/122	188 (70%), 165 (15%), 122 (15%)
0304020002670027	65%/188, 21%/165, 11%/122	188 (70%), 165 (15%), 122 (15%)
0304020002670029	65%/188, 31%/122	188 (70%), 165 (15%), 122 (15%)
0304020002670019	34%/188, 33%/161, 16%/122, 15%/165	188 (70%), 165 (10%), 122 (10%), 161 (10%)
0304020002670021	52%/188, 25%/122, 16%/165	188 (70%), 165 (10%), 122 (10%), 161 (10%)
0304020002670022	90%188, 5%/122, 5%/165	188 (70%), 165 (10%) 122 (10%), 161 (10%)
0304020002670030	68%/188, 12%/161, 11%/122, 7%/165	188 (70%), 165 (10%), 122 (10%), 161 (10%)
0304020002670031	81%/188, 14%/165	188 (70%), 165 (10%), 122 (10%), 161 (10%)
0304020002670018	45%/161, 38%/188, 14%/165	188 (50%), 165 (50%)
0304020002770029	56%/188, 42%/165,	188 (50%), 165 (50%)
All Mormon Mountain Stands		188 (50%), 165 (50%)

Compute Statement for Fuels Output:

```
Compute      0
DWDac = FuelLoad(1,9)
CBH = CrBaseHt
CBD = CrBulkDn
TorhIdx = TorchIdx
CrwnIdx = CrownIdx
FL_S = PotFLen(1)
FL_M = PotFLen(2)
Mort_S = PotFMort(1)
Mort_M = PotFMort(2)
TPA_All = SpMcDBH(1,All,0,0.,200.,0.,500.,3,0.)
BA_All = SpMcDBH(2,All,0,0.,200.,0.,500.,3,0.)
QMD_ALL = SpMcDBH(5,All,0,0.,200.,0.,500.,3,0.)
End
```

Appendix 5: Monitoring Information

MONITORING FOR MANAGED FIRE AND PRESCRIBED FIRE

Compiled and created by Kristin Kolanoski

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Located at O:\NFS\Coconino\Program\5100Fire\5150FuelMgmt\fcntr\Monitoring_protocols

The purpose of this document is to outline the protocols and standards used by fuels and fire personnel to monitor the fire effects on ecosystem components within areas burned by managed fire and/or by prescribed fire on the Flagstaff Ranger District of the Coconino National Forest.

Specific protocols have been developed from a combination of the Firemon and FSVeg protocols and following the DRAFT Region 3 Vegetation Monitoring/Sampling Protocols (updated December 2008) included in this 3 ring binder. The forest characteristics that are measured pre and post fire/prescribed burn in the managed fire and prescribed fire protocols are described below in detail and include overstory trees, pole sized tree or saplings, seedlings, snags, fuel loading, and CBI (composite burn index which assessed burn severity) which is solely performed postfire and under special severe wildfire or prescribed fire situations. CBI methodology and protocols will only be implemented when the FRD fuels specialist deemed necessary.

MANAGED FIRE PROTOCOLS- The number of plots within a burned area will be determined based on the acreage within the planned fire area delineated in WFDSS(the area that could be potentially burned and not the planning area (the area potentially affected by the fire, i.e. by smoke)), the number of stands represented within the potentially burned area, and based on the degree of heterogeneity and/or homogeneity of stand conditions within the potentially burned/fire area.

Prior to monitoring plots, the number of plots to be monitored within the fire area will be specifically determined by:

1) Looking at stand boundaries within the planned fire area in GIS,
2) Using random plot generator (not systematic random) in ArcMap tools, random plots will be generated based on acreage of planned fire perimeter and stand(s) heterogeneity,
3) Locations of plots will be created using ArcMap tools; 300 ft buffer around roads and fire perimeters/burn block boundaries will be determined in ArcMap; locations will be deemed plot plot locations if the locations meet the following criteria:
    a. Not solely rock cover (<40%)
    b. Location is at least 10% forested.
    c. No unusual disturbances within and around the location

Areas that are on slopes 30% or greater will be avoided for plot installation. However, if plots do occur on steep slopes (slopes > 15%), slope correction factor needs to be applied and plot size and fuels transect size needs to be adjusted accordingly.

Each location will be visited in the field to verify that it meets the above criteria before chosen and installed as a permanent plot. Each stand should consist of at least 3 plots (minimum). A stand is an easily defined area of the forest that is relatively uniform in species composition and/or age and can be managed as a single unit. In most cases, GIS stand layer for the Coconino NF should be used to determine stand boundaries within the area of interest.

According to Region 3 protocols guidelines :

> It is recommended that 3 plots be sampled per stand no matter the size of the stand. If time and funding allows it is further recommended that the following number of plots based on stand size be sampled(assuming homogeneous stands):

Stand Size in Acres	# of plots
0-20	3
21-50	4
51-70	5
71-90	6
91-110	7
111-200	8-9
201-400	10

Not all stands within a treatment area need to be sampled. Stands to be sampled should be homogeneous and should represent the landscape being sampled.

4) IDEALLY- 2 to 4 control plots should be established outside the area within the planning area and that will be potentially burned or will potentially burn. These areas/plots need to be representative or be comparable to stand conditions being monitored within the fire planning area (burned areas) and should not be located in areas that could possibly be burned or burn. Control plots will be installed based on time and personnel available to perform such tasks.
5) Plots will then be numbered in GIS and a map will be created to reflect locations and names of plots within the fire planning area.
6) Plots will be downloaded onto to field crew GPSes using DNRGPS to locate plots in the fire planning area. Plot numbers on GPSes need to correspond/be the same as the labels of plots on the field maps.

Monitoring plots in the field will consist of performing pre and post data collection at each of the planned plots. Controls will only be measured once. If funding and time is available, burned plots should be visited *a)* immediately post burn(ideally 2 weeks to 1 month after fire is controlled but can wait up until 1 year postburn), *b)* 5 years postburn on same date as the immediate postburn monitoring occurred, AND c) 10 years postburn on same date if maintenance burning has not taken place yet. Immediate postburn is good to show how much fuel was consumed as a result of the burn, however, waiting one year postburn to monitor is also beneficial because 1 year postburn monitoring will hopefully show delayed fire effects to ecosystem components (tree scorch, vegetation regrowth, soil burn severity (if veg regrows or not in severely burned areas or have soil erosion), tree death/snag creation, etc) and any beneficial regrowth or retarded regrowth 1 year after postburn.

A field crew of three people has shown to be the most efficient for implementation of the sampling method. A crew of more than three people will require excessive walking and trampling on the plot which should always be avoided. Also, any more than three people will probably result in some people waiting for critical tasks to be done and unnecessary physical damage to the plot.

Monitoring protocols consist of:

NAVIGATION TO PLOTS/ INSTALLATION OF REBAR

1) Field crews will use Garmin GPS to navigate to each of the plot locations. The datum setting on Garmin GPSes (76 or 60, Oregon 400t, 78, or 62) needs to be set to NAD83. Navigation to plot needs to be within 15 feet of plot center according to GPS.
2) Hammer a piece of red painted rebar (1 ½ to 2 feet long) at plot center. Record plot center on GPS using averaging waypoint option on GPS. Collect at least 100 points before saving the location on the GPS. Record the plot center with plot number and name of fire. For example, 1_Fly . For prescribed fire, record plot center with plot number and name of burn block. For example, 3_Mountainaire5 describes plot 3 of Mountainaire burn block #5. The GPS will not take long names so shorten the project area name and be consistent throughout plot monitoring in the project area.
3) Please record slope along fuels transect. If slope of fuels transect is greater than 15%, please use slope correction factor table to correct for slope and make transect longer. You will also do this for each individual tree to see if the tree is within the plot radius when a tree is on a slope greater than 15%.

SETTING UP PLOT CONFIGURATION

1) End of plot center rebar should be painted red for ease of rebar location for post monitoring. Two rebar will be installed 50 feet due north and 50 feet due south of plot center. These two rebar will be painted blue and will represent the end of the Brown's transects. Two Brown's transects (fuels transects) will be read in each plot.
2) Place end of transect tape on end of rebar. Determine NORTH with declinated compass (10.9 degrees EAST for Flagstaff, Arizona). Walk out 37.24 feet (or 11.28 meters) which is 1/10th acre plot size. This will be plot size used for measuring overstory tree data. This size was determined based on breakpoint diameter of trees within stands. Plot size of 1/10th acre should allow at least 20 trees with a dbh of 4 inches or greater to be measured on each plot, on average.
3) Take two photos of plot- one facing due north, and second one facing due south (each showing approximately one half of the plot in each photo). Do not take photo directly into Sun. Also, use dry erase board or dry erase sheets attached to tatum- write date, burn block number and plot number, RX or managed fire name, N-S or S-N according to direction photo is being taken for that transect, all data collectors initials, and preborn, post 1 yr, post 5 yr, or post 10 yr on board for identification and scale purposes.
4) Starting from declinated/magnetic north and PROCEED CLOCKWISE ONLY,
    - Tag first tree from due North of plot center. The tag should read the burn block number and plot number on it and should be installed at DBH facing plot center.

Use stamp kit to stamp tag with appropriate information. Use aluminum tags and nails. Record species, live or dead, dbh (must be taken at 4.5 inches –at breast height and on uphill side of the tree if it is on a slope, and must be measured to the nearest 0.10 inch)or drc (diameter at root collar, for junipers and oaks), total height using the laser(needs to be measured to nearest foot), live crown ratio, crown base height, and note any obvious signs of insect infestation/disease/severe deformity of each tree that has a dbh = or greater than 4 inches. It is VERY IMPORTANT that trees are numbered and measured according to their location from declinated north. **PLEASE DON'T GO OUT OF ORDER**. Status classes are: Live (L) or Dead (D). Dead trees that do not fall within the definition of a snag (see below under measuring snags, step #7) but lie within the 1/10th acre plot will be measured and recorded on the tree data sheet. Once again a tree that is on a slope greater than 15% from plot center needs to be checked to see it is in the plot using the slope correction factor table.

- Record live and dead trees greater than 4.5 inches in height but whose dbh is less than 5 inches. These trees are considered saplings. Plot size for saplings is the same as for overstory trees (37.2 ft radius or 1/10th acre plot). Record sapling number, tree species, dbh class read to the 0.1 inch, height class read to the nearest 1 foot and any comments including severe damage(type) or any unique situations. DBH classes are: 1 = <0.5 to 1.5 in, 2 = >1.5 to 2.5 in, 3 = >2.5 to 3.5 in, 4 = > 3.5 to 4.5 in, 5 = 4.5 in< DBH < 5 inches.
- Please do these two sampling tasks at the same time because it will be difficult determining which trees have been measured especially in dense plots.

5) After overstory trees and saplings are measured, establish regeneration/seedling nested plot by placing end of transect tape at the end of rebar and walk out 11.77 feet (or 3.57 meters) from plot center. This is a 1/100th acre sized plot.
6) Starting from declinated NORTH and proceeding clockwise (ALWAYS), tally seedlings (4.5 inches or 1.37 meters in height) by species into their respective status (live or dead) and height classes as a crew member sweeps clockwise around the plot, holding the tape just above the seedlings, maintaining a nested plot radius of 11.77 feet. Height classes (in feet) are W= > 0 to 1.0 ft; X = > 1.0 to 2.0 ft; Y = > 2.0 to 3.0 ft, Z = 3.0 < Height<4.5 ft. If a tree is broken below 4.5 feet but the crew members believe that the tree would be taller than 4.5 feet if unbroken, crew member should still sample it as a seedling or if the crew member can see the broken top on the ground or hanging from the tree, record as sapling or tree and make note in the comments section.
7) Walk out 117 feet for snag plot radius (laser can be used at plot center to determine 117 feet from plot center). Starting from declinated NORTH and proceeding clockwise, record species and measure height, dbh, and decay class. Snags are considered ≥ 12 inches dbh and 15 feet tall. Other dead trees that fall within the 37.2 feet radius plot but do not meet the definition of a snag (5<dbh<12 and/or height <15 ft) still need to be recorded on the tree data sheet. Also, postburn monitoring may show some trees that were live before the burn and are dead postburn. In this example, this tree may be "moved" to the snag data sheet if it meets the criteria of a snag. Make a note of it in

comment section on snag sheet that it once was an overstory tree but is dead and is now considered a snag postburn.

8) ESTABLISHING FUELS TRANSECTS- Using transect tape, walk out from plot center 0 degrees(NORTH) or 180 degrees (SOUTH), hammer rebar into ground (end of rebar needs to be painted blue)-doing this will be easier to locate the exact fuels transect when performing post monitoring. Perform fuel loading surveying using Brown's protocols. Do the same procedure but walk out from plot center 180 degrees from due North (SOUTH). Two 50 foot fuel loading transects will be completed /read in one plot.

Post fire monitoring-

All of the above protocols should be measured in post fire monitoring. Only if the fuel specialist deems it necessary and the fire is >1000 acres, CBI monitoring should be conducted. However, these plot locations will not necessarily be the same as the plots established for prefire/burn monitoring due to heterogeneous fire effects in that area/edge effects and those edge effect plots not meeting the needs of CBI plot monitoring. Additional plots most likely will be established specifically for CBI monitoring. Plots for CBI monitoring need to: 1) represent the range of variability found at the site, 2) fall within relatively large homogeneous areas, preferably 200x200feet of basically the same fire effects. This allows a plot to be placed somewhat centrally in the larger area, to be representative yet not too close to adjacent areas exhibiting different fire effects. Too close depends on remote sensing resolution. Rule of thumb- try to stay at least 150 feet from the edges. Plots should be spaced at least 300 feet apart.

CBI plot monitoring protocols-

1) Navigate to plot center within 15 feet using Garmin GPS. Record plot center using GPS in averaging mode. Collect GPS location in UTM coordinates to the nearest meter, noting zone number (should be 12), geodetic datum (needs to be NAD83), and the amount of error when you save the GPS location (on GPS screen) to make sure all makes sense. Average location for at least 10 minutes.
2) Take photos of plot (3 photos as described above).
3) Determine a 100ft diameter (50 ft radius) from center plot.
4) Follow BI (CBI) data form to rate the different substrates and strata within the 100ft diameter (50ft radius) plot. Ensure that the form is completely filled out. Only rate those strata/substrates that apply (that were there before the fire burned through the plot). Please record NR if substrate/strata were not applicable to/were not used to rate the plot.

Prescribed Fire monitoring- The protocols outlined for managed fire will also apply to prescribed burning monitoring. The only difference is that CBI plot monitoring will not be performed for prescribed fire unless the fuel specialist has deemed it necessary . The following criteria can help with making the decision: Prescribed burn is >1000 acres and/or a broad range of fire effects resulted from the burn.

- All hard copies of data sheets/data collected needs to be stored in the 3 ring monitoring binder for each project area. Data sheets and photos should be placed in sheet protectors. Protectors will help maintain sheets when they are taken out into the field for postburn monitoring.

- All data should be entered into FSVeg as soon as possible after monitoring has been completed (pre and post). Tessa Nicolet can help with teaching how to set up criteria for entering and accessing data in FSVeg database. A NRM FSVeg profile (roles established- I think Shawn Martin is the contact) will need to be established in order to input data into FSVeg.
- Quality assurance of data collected needs to be performed. This requires Fuels Crew leader visiting each plot and ensuring that data collected by crew members has met within error range indicated on data collection sheets.
  Error compared to plot checker: DBH (+ 0.2 in), Height (+ 2 ft), Crown Ratio (+ 5%), CBH (+ 1 ft)
  If plot checker finds many errors with the data, the plot needs to be remeasured. Any comments need to be made regarding differences in transect direction and/or plot center needs to regpsed using the averaging feature if the coordinates do not agree with actual location. These new coordinates need to be recorded on the data sheet and on plot location map.
- All pictures should be downloaded/saved onto the O drive at the following location: **O:\NFS\Coconino\Project\Flagstaff\FuelsProjectImpleMonitor\Monitoring_photos** as soon as possible after monitoring has been completed. Photos of plots preborn and postburn should also be printed out and placed in monitoring 3 ring binder. Photos can be helpful in locating the plot especially if elk or other wildlife have ripped out rebar of the plot.

During burning:

- A FEMO/FOBs or someone who can spin weather/record weather observations and take pictures throughout the burn should be designated for every prescribed burn and during shifts when plots burn in a managed fire situation.
- These weather observations and during burning photos should be filed in the 3 ring monitoring folder for that particular project area.
- It is also ideal if a burn boss packet is placed in the during burning section of the 3 ring binder to keep track of any special circumstances or additional information that may be useful during analysis of the pre and postburn data.